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THE

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AND

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THE MINERALOGICAL SOCIETY

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 15, 1904.

Dr. Hugo Müller, F.R.S., President, in the Chair.

The death of Dr. Henry P. Gurney, Ordinary Member of the Society, was announced.

The following Candidates were elected Ordinary Members of the Society:—Mr. Thomas Vipond Barker, B.A., and Mr. John Woodgate, M.I.M.M.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 15, 1904.

Dr. Hugo Müller, F.R.S., President, in the Chair.

Twenty-two Members were present.

The elections of Mr. T. V. Barker and Mr. J. Woodgate to the Ordinary Membership of the Society were confirmed.

The scrutineers reported that thirty-eight voting papers for the election of Officers and Council had been returned to the General Secretary, and that the List as nominated by the Council was approved, namely:—

President. Prof. H. A. Miers, M.A., D.Sc., F.R.S.

Vice-Presidents. Prof. W. J. Lewis, M.A., F.C.S.
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J. W. Evans, Esq., LL.B., D.Sc., F.G.S.
The Rev. J. M. Gordon, F.G.S.
J. A. Howe, Esq., B.Sc., F.G.S.
A. Hutchinson, Esq., M.A., Ph.D., F.G.S.

The following ANNUAL REPORT OF COUNCIL was read:—

The Balance Sheet for the year ending December 31, 1903, which has already been published in No. 63 of the Journal, shows that the Assets of the Society (exclusive of the Library and the Stock of the Journal) amounted to £625 10*s.* 6*d.*, and that the Liabilities amounted to £69 0*s.* 9*d.*

The number of Life-Members on December 31, 1903, was fifty-two; the value of the Stock invested in the names of the Trustees of the Society was on that date £547 9*s.* 10*d.*, corresponding to £10 10*s.* 7*d.* for each Life-Member.

During the Session 1903–4 the Society has lost by death five Ordinary Members (Mr. Dickson, Professor Le Neve Foster, Dr. Gurney, General McMahon, and Mr. Rutley) and two by resignation (Mr. Adcock and Mr. Rich); one Honorary Member (Professor Fouqué) has died. On the other hand, three Ordinary Members (Mr. Campbell, Mr. Grabham, and Mr. Rastall) were elected at the last Anniversary Meeting, and Professor Penfield has since been added to the list of Honorary Members.

The total number of Members (on November 14, 1904) is 122; of these nineteen are Honorary, and 103 Ordinary Members; of the latter fifty are Life-Members, and fifty-three are Annual Subscribers.

Four Meetings have been held during the year, all in London and (by kind permission) in the Apartments of the Geological Society, Burlington House, London, W.

Two Numbers of the Journal, Nos. 62 and 63, published respectively in December, 1903, and October, 1904, have been issued; the former concludes Volume XIII, and has been provided with an index by Mr. Spencer; with the latter is a new List of Members (corresponding to September, 1904) and a reprint of the Bye-Laws as amended at the Anniversary Meeting of 1902. For the abstracts the Society is indebted to Mr. Spencer and Mr. Hutchinson.

The Council has to congratulate the Society on its continued prosperity.

On the motion of the President, seconded by Dr. Scott, the Report was adopted. A vote of thanks to the Geological Society for the permission to meet in its Apartments was carried with acclamation.

The newly-elected President, Professor Miers, having taken the Chair, the following papers were read:—

1. On some new forms of quartz-wedge and their uses: by Dr. J. W. Evans (p. 87).

2. On an improved form of refractometer: by Mr. G. F. Herbert Smith (p. 83).

3. On the discovery of Bertrandite in Cornwall: by Mr. H. L. Bowman.

4. On Marrite, Lengenbachite, and Bowmanite, three new minerals from the Binnenthal: by Mr. R. H. Solly (p. 76).

5. On some curious crystals of Blende: by Mr. R. H. Solly (p. 81).

6. Note on some new localities for Gyrolite and Tobermorite: by Mr. James Currie (p. 93).

7. Note on the occurrence of Brookite in the Cleveland ironstone: by Mr. C. R. Lindsey (p. 96).

8. The construction of crystallographic projections: by Mr. Harold Hilton (communicated by Professor Miers) (p. 99).

9. Some applications of the gnomonic projection to crystallography: by Mr. Harold Hilton (communicated by Professor Miers) (p. 104).

In addition to specimens illustrative of the papers, Mr. Arthur Russell exhibited a large specimen of 'babel-quartz' which he had found at Great Work mine, Breage, Cornwall.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, January 31, 1905.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Dr. Wilbert Goodchild was elected an Ordinary Member of the Society.

Mr. H. F. Collins and Mr. B. Kitto were appointed to audit the accounts of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, January 31, 1905.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Twenty-two Members and four Visitors were present.

The election of Dr. Wilbert Goodchild to the Ordinary Membership of the Society was confirmed.

The following papers were read:—

1. On Danalite from Cornwall: by Professor H. A. Miers.

2. Crystallographic characters of barium-radium bromide: by Professor H. A. Miers.

3. On an Epidote from Inverness-shire: by Mr. H. H. Thomas (p. 109).

4. On the regular growth of crystals of one substance upon those of another: by Mr. T. V. Barker.

5. Apparatus for determining the density of small grains: by Mr. K. A. K. Hallowes (communicated by Dr. J. W. Evans).

In addition to specimens illustrative of the papers, Mr. Arthur Russell exhibited a specimen of phenakite and one of aurichalcite from Cornish localities, and Mr. H. F. Collins specimens of sulphide of lead and oxide of zinc, artificially produced at Laurium.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, March 15, 1905.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

The Secretary reported that Mr. L. J. Spencer had sent in to the Central Bureau of the International Catalogue of Scientific Literature 451 slips relative to titles of mineralogical and crystallographical papers published in the United Kingdom during the year 1904.

The Editorial Committee appointed on March 25, 1902, was re-appointed, Professor Miers and Dr. Müller interchanging places.

GENERAL MEETING.

Held in the Apartments of the Geological Society, March 15, 1905.

Professor H. A. Miers, D.Sc., F.R.S., President, in the Chair.

Twenty-two Members and one Visitor were present.

The following papers were read:—

1. Description of the big Diamond recently found at the Premier Mine, Transvaal: by Dr. F. H. Hatch and Dr. G. S. Corstorphine (communicated by the President).

2. On some new mineral localities in Cornwall and Devon: by Mr. Arthur Russell.

3. On a crystal of Phenakite from German East Africa: by Mr. L. J. Spencer.

4. Notes on various minerals from the Binnenthal, Switzerland: by Mr. G. T. Prior and Mr. G. F. Herbert Smith.

5. On a new oxychloride of copper from Sierra Gorda, Chili: by the same.

6. On Dundasite from Wales: by Mr. G. T. Prior.

Dr. Hatch exhibited a model and lantern-slides in illustration of his paper, and the President exhibited lantern-slides relating to the Premier and Kimberley Diamond Mines.

MINERALOGICAL SOCIETY.

ABSTRACT OF RECEIPTS AND PAYMENTS FROM JANUARY 1 TO DECEMBER 31, 1904.

Receipts.	£ s. d.	£ s. d.
Balance from 1903		55 4 1
Subscriptions—(1) current	47 4 0	
(2) arrears	12 3 6	
(3) in advance	2 2 0	
		61 9 6
Entrance fees and compositions		23 2 0
Sale of publications by publishers (1903)	12 16 0	
Do. by G. Savigar (1903)	0 11 7	
		13 7 7
Dividends on Stock		15 2 6
		£168 5 8

Payments.	£ s. d.	£ s. d.
Printing Magazine (No. 62)	39 19 4	
Authors' separate copies	5 3 9	
Illustrations	4 11 6	
		49 14 7
Miscellaneous Printing		4 14 10
Editor's Honorarium (1903)		10 10 0
International Catalogue slips		0 7 10
G. Savigar for care of Stock		1 1 0
Postage and Parcels		3 0 4
Porter's Fee		1 0 0
Bank Charges		1 0
Investments		15 2 6
Balance at Bank	81 0 10	
„ in Office	1 12 9	
		82 13 7
		£168 5 8

Examined and compared with the vouchers, and found correct. (*Signed*) BENEDICT KITTO, HENRY F. COLLINS } Auditors.

Liabilities.	£ s. d.	Assets.	£ s. d.
Owing for Printing, &c., of No. 63 of Magazine	38 2 8	Balance at Bank	81 0 10
„ Editor's Honorarium (1904)	10 10 0	„ in Office	1 12 9
„ Miscellaneous Printing	5 3 7	Consols (£646 3*s.* 10*d.*, valued at £88)	569 1 10
„ G. Savigar for care of Stock (1904)	1 1 0	Balance owing from Publishers	24 12 6
„ Do. for postage	0 6 9	„ „ „ G. Savigar	0 15 4
„ Secretary's postage (1904)	1 6 11	Subscriptions in arrear, valued at	5 5 0
„ Treasurer's „ (1904)	0 8 9		
Excess of assets over liabilities	625 8 7		
	£682 8 3		£682 8 3

The number of Life-Members on December 31, 1904, was 51.

The Stock of Publications and the value of the Library are not included in the above assets.

(*Signed*) W. P. BEALE,
Hon. Treasurer.

February, 1905.

THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY.

No. 64. May, 1905. Vol. XIV.

A new device for separating minerals by means of heavy liquids.

By HAROLD HARTLEY, M.A.
Fellow of Balliol College, Oxford.

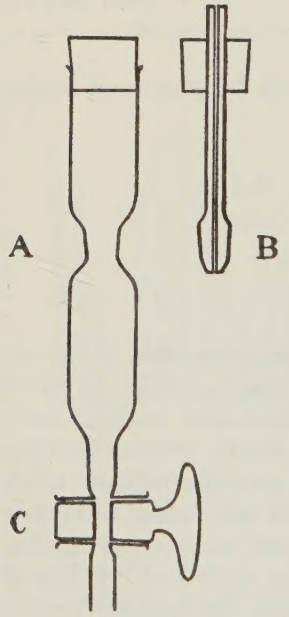
[Read January 22, 1901.]

DURING the investigation of a zeolite it became necessary to separate small quantities of zeolitic material from a mixture of calcite and other heavier minerals; this could be done most easily by using a liquid of such density that the zeolite just floated, while all the other minerals sank to the bottom. A solution of potassium-mercuric iodide could not be used, as this reacts chemically with zeolites and alters their composition; acetylene tetrabromide diluted with benzene was therefore chosen, and in consequence the apparatus had to be made entirely of glass. Certain difficulties were found in using the ordinary form of glass separating apparatus, and to overcome these the form here described was devised.

The accompanying figure shows the apparatus in section and about one-third its actual size; it consists of a glass tube A, about 22 cm. long, and 2·5 cm. wide, slightly constricted in the middle, and closed by a wide-bore Geissler-tap C at its lower end. The powdered mixture of minerals is introduced into A with an organic liquid of suitable density for separating its lightest or heaviest constituent. The tube is closed by a cork or glass stopper to prevent evaporation and consequent change of density in the liquid. It is gently shaken by short, rapid movements, up and down and from side to side, so as to allow the lighter particles to rise,

and by continuing this long enough it is possible to prevent the entanglement of either light or heavy particles in the wrong part of the liquid. It is also advisable to incline the tube at an angle of 45°, rotating it and tapping it at the same time, to make sure that no particles are adhering to the glass near the constriction.

When the separation seems to be complete, the cork is taken out and replaced by another carrying the capillary-tube B, which is thickened at its lower end and ground so as to fit the constriction in A. When B has been pushed home, the lower tap is opened and the liquid flows out, carrying with it the heavier portions of the powder; these can be filtered off, and the heavy liquid is ready for use again.



Separator.

Some particles always remain attached to the inside of A; these are washed out with the liquid that is being used as a diluent (in this case benzene) by sucking up a little through C by means of a rubber-tube attached to the end of the capillary-tube B, then closing the tap C, swilling out the tube, and letting the liquid run out of the tap again. By repeating this operation the lower chamber can be freed from any trace of solid; and by closing the tap C and removing the capillary-tube the liquid flows down from the upper chamber, and if required can be allowed to flow out and can be filtered like that from the lower, the adhering particles being washed out with the same lighter liquid.

The apparatus has mainly been used in cases where it was required to separate a very small percentage of the lightest constituent from a large quantity of material, and it was found convenient not to remove the lightest portion from the apparatus at the end of each separation, but when the heavier part has been removed, the liquid is poured in again, another portion of material added, and the process repeated. In this way the lightest portion is concentrated and no loss is incurred by successive separations; and the method gives very satisfactory results both as regards yield and purity.

The following were found to be the chief advantages over the ordinary forms of 'all glass' apparatus.

In other 'all glass' separators, after the powdered mixture has been separated by the heavy liquid, the latter is allowed to flow out at the bottom of the tube in which the separation has taken place, and, when only the lightest solid remains, the flow is interrupted by turning a tap or inserting a ground-glass plug. In both cases some solid is apt to get into the joint and spoil the experiment and not infrequently break the apparatus. This possibility is prevented in the apparatus described, as the tube B is inserted while the liquid is at rest and it is easy to see that there are no particles in the joint. Another advantage is the possibility of using it as a concentrator in the way mentioned.

The apparatus can be obtained from Messrs. Müller, Orme & Co., 148 High Holborn, London.

Some new minerals from the Binnenthal, Switzerland.

By R. H. Solly, M.A.

[Read November 17, 1903, and November 15, 1904.]

Hutchinsonite.

A PRELIMINARY notice of this new mineral, named in honour of Dr. Arthur Hutchinson, Demonstrator of Mineralogy in the University of Cambridge, was read before the Cambridge Philosophical Society in October, 1903 [1]. The material was first found, in the white crystalline dolomite of the Lengenbach quarry, during my visit to the Binnenthal in the summer of 1903. More material was received in November of the same year, and a further supply was obtained in 1904 [2].

The characters of hutchinsonite, so far as yet determined, are the following:—

System: orthorhombic. $a : b : c = 0{\cdot}8175 : 1 : 0{\cdot}7549$.

$(100) : (110) = 39° 16'$; $(010) : (011) = 52° 57'$; $(001) : (101) = 42° 43'$.

These elements are calculated from the measured angles

$$(100) : (340) = 47° 28' \text{ and } (100) : (101) = 47° 17'.$$

The usual habit is a flattened rhombic prism [100,010], with numerous small dome- and pyramid-faces. The plane (180) is very common and often very largely developed.

The colour is red to greyish-black, the red being sometimes lighter and sometimes darker in shade. The streak is vermilion. The crystals are transparent to nearly opaque. Hardness, $1\frac{1}{2}$ to 2. Cleavage, parallel to (100), good.

Hutchinsonite usually occurs as very small crystals in the white dolomite, or is closely associated with sartorite and rathite. In the latter case two modes of occurrence may be distinguished: (1) as small, dark red prisms symmetrically arranged on the prism-planes of the sartorite or rathite; (2) as small, stout, light red crystals coating the terminal planes of these minerals.

In the preliminary account, quoted above, it was stated that the new

[1] Proc. Cambridge Phil. Soc., 1904, vol. xii, p. 277. The new mineral is there briefly described, but without name.

[2] Leaving England in December, 1903 for an indefinite period, I handed over the whole of this material, together with the other red minerals—smithite and trechmannite—to the British Museum for the investigation to be completed. A fuller account, by Mr. G. T. Prior and Mr. G. F. Herbert Smith, of these new minerals will therefore appear in a subsequent number of this magazine.

mineral contains arsenic, sulphur, and probably lead; but owing to its very intimate association with sartorite and rathite, and in the absence of any confirmatory tests, this must be considered to be doubtful [1].

The following is a list of the best developed faces; I have also observed a number of other smaller ill-defined planes:—

{100}, {010}, {001}, {850}, {870}, {110}, {780}, {340}, {580}, {120}, {380}, {140}, {180}, {502}, {201}, {302}, {101}, {304}, {102}, {104}, {011}, {322}, {111}, {344}, {122}, {144}.

A selection of the angles measured on hutchinsonite is given below:—

	Calculated.	Measured.	
Zone [100,010].			
(100) : (850)	= 27° 3½′	26°56′	
: (870)	= 35 34½	35 51	35°49′
: (110)	= 39 16	39 20	
: (780)	= 43 3	43 4	43 2
: (340)	= 47 28	47 25	47 28
: (580)	= 52 36	52 39	52 30
: (120)	= 58 33	58 36	58 32
: (380)	= 65 21½	65 29	65 21
: (140)	= 73 0	72 55	73 3
: (180)	= 81 21	81 19	81 21
: (010)	= 90 0	90 0	
Zone [100,001].			
(100) : (502)	= 23 25½	23 35	
: (201)	= 28 26	28 24	28 28
: (302)	= 35 50	35 45	
: (101)	= 47 17	47 17	47 19
: (304)	= 55 17	55 32	
: (102)	= 65 13	65 15	
: (104)	= 77 0	77 1	
: (001)	= 90 0	90 0	
Zone [100,011].			
(100) : (322)	= 42 7	42 10	
: (111)	= 53 36½	53 36	53 37
: (344)	= 61 3½	61 4	61 6
: (122)	= 69 46	69 50	
: (144)	= 79 33½	79 30	

[1] Quite recently, Mr. G. T. Prior has found hutchinsonite to be a sulpharsenite of thallium, lead, silver, and copper: the presence of nearly 20 per cent. of thallium is of especial interest ('Nature,' April 6, 1905, vol. lxxi, p. 534).

Smithite.

System: monoclinic. $a : b : c = 2{\cdot}2309 : 1 : 1{\cdot}9657$; $\beta = 78° 47\frac{1}{2}'$. $(100) : (101) = 42° 22'$; $(101) : (001) = 36° 25\frac{1}{3}'$; $(010) : (111) = 37° 3'$. These elements are calculated from the angles $(100) : (101) = 42° 22'$, $(100) : (10\bar{1}) = 55° 0'$, and $(100) : (111) = 63° 24'$, measured on the best and largest crystal.

The usual habit resembles a flattened hexagonal pyramid with basal plane, the plane (100) being largely developed and combined with the three zones [100,001], [100,111], [100,11$\bar{1}$] equally developed

The colour is light red. Lustre, adamantine. Streak, vermilion. The crystals are transparent to translucent. Hardness, 1½–2. Cleavage, parallel to (100), highly perfect. The surface of the crystals becomes altered on exposure to light, changing from a pure red to an orange-red colour.

Smithite is associated with hutchinsonite, sartorite, and rathite in the white dolomite of the Lengenbach.

Sixteen forms were observed, viz.:—

{100}, {001}, {101}, {10$\bar{1}$}, {411}, {311}, {211}, {322}, {111}, {355}, {011}, {51$\bar{1}$}, {41$\bar{1}$}, {21$\bar{1}$}, {11$\bar{1}$}, {21$\bar{2}$}.

	Calculated.	Measured.	
Zone [100,101].			
(100) : (101) =	42°22′	42°22′	42°24′
: (001) =	78 47½	78 47	78 45
: ($\bar{1}$01) =	125 0	125 0	125 0
Zone [100,011].			
(100) : (411) =	30 0	30 5	30 0
: (311) =	37 7	37 7	37 9
: (211) =	47 43	47 45	47 42
: (322) =	54 50	54 49	
: (111) =	63 24	63 24	
: (355) =	71 25	71 23	
: (011) =	84 50	85 0	
($\bar{1}$00) : ($\bar{5}$11) =	27 1½	27 4	
: ($\bar{4}$11) =	32 49½	32 11	
: ($\bar{2}$11) =	53 52½	53 53	
: ($\bar{1}$11) =	72 16	72 11	
: ($\bar{2}$12) =	83 27½	83 48	
: (011) =	95 10	94 57	

I have named this mineral after Mr. G. F. Herbert Smith, M.A., Assistant in the Mineral Department of the British Museum [1].

Trechmannite.

After the discovery of the two red minerals described above, I received from Dr. C. O. Trechmann a specimen with a few minute red crystals resting on a crystal of baumhauerite in a cavity in the white dolomite. It was necessary to remove the crystals from the matrix for examination, and it was found that in symmetry they differed from both hutchinsonite and smithite. I therefore distinguish this third red mineral by the name trechmannite, after Dr. Charles O. Trechmann, who for many years has worked at the minerals of the Binnenthal. Dr. Trechmann's specimen was taken from the Lengenbach quarry in the summer of 1902; a second specimen, with a single crystal of trechmannite resting on a crystal of tennantite was found in 1904.

The following characters have been determined:—

System: rhombohedral. $(111):(100) = 37° 7\frac{1}{2}'$. $a:c = 1:0{\cdot}6556$.

The element was calculated from $(1\bar{1}0):(100) = 58° 29'$ observed on two crystals.

The two crystals which were measured consist of portions of hexagonal prisms with some small pyramidal and rhombohedral faces. One crystal exhibits a cleavage perpendicular to the prism.

In colour, streak, and hardness it resembles hutchinsonite and smithite.

The following is a list of forms observed:—

$o\{111\}$, $r\{100\}$, $x\{21\bar{2}\}$, $z\{31\bar{3}\}$, $a\{1\bar{1}0\}$, $b\{2\bar{1}\bar{1}\}$, $d\{52\bar{7}\}$, $f\{32\bar{5}\}$.

There are also a number of narrow planes lying in the zone $[10\bar{1},010]$.

	Calculated.	Measured.
$(10\bar{1}):(52\bar{7}) =$	16° 6′	16°17′
$(10\bar{1}):(32\bar{5}) =$	23 25	23 23
$(10\bar{1}):(1\bar{1}\bar{2}) =$	30 0	29 57
$(10\bar{1}):(01\bar{1}) =$	60 0	60 0
$(10\bar{1}):(31\bar{3}) =$	17 41	17 43
$(10\bar{1}):(21\bar{2}) =$	25 33½	25 34
$(10\bar{1}):(010) =$	90 0	89 55
$\bar{1}01):(\bar{2}12) =$	25 33½	25 30

	Calculated.	Measured.
$(10\bar{1}):(100) =$	58°29′	58°29′
$(100):(001) =$	63 2	63 1
$(01\bar{1}):(21\bar{2}) =$	47 25	47 25
$(1\bar{1}0):(21\bar{2}) =$	76 57	77 1
$(21\bar{2}):(11\bar{2}) =$	26 6	26 12
$(10\bar{1}):(111) =$	90 0	90 0
$(\bar{1}10):(111) =$	90 0	90 0

[1] Since the above was written an analysis of smithite has been made by Mr. G. T. Prior, the results of which lead to the formula $AgAsS_2$.

Marrite.

The crystals of this new mineral are highly modified and are usually doubly terminated. They are tarnished with red, yellow, and blue colours, and on this account might, at first sight, be mistaken for tennantite ('binnite') or iron-pyrites. The only specimen, which up to the present time has been found, was taken from the Lengenbach quarry in July, 1904. On the matrix of white crystalline dolomite there are about fifteen small crystals, averaging 2–3 mm. across, of marrite deposited on or about tarnished crystals of lengenbachite (p. 78) and iron-pyrites. Three crystals were removed from the matrix; two being measured with the results given below, and the third, after goniometric verification, being used for determining the streak and hardness of the mineral. The specific gravity and chemical composition of the crystals could not be determined without sacrificing the unique specimen.

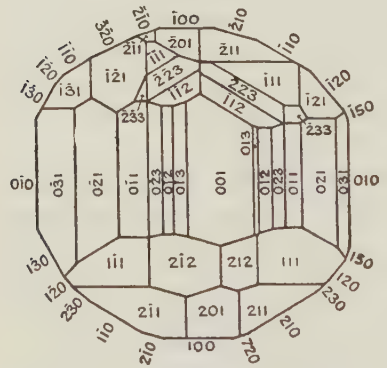


Fig. 1.—Orthographic projection of marrite.

The system of crystallization is monoclinic, with the elements:—

$$a : b : c = 0{\cdot}57634 : 1 : 0{\cdot}47389;$$
$$\beta = 88^\circ\,45',$$

as calculated from the measured angles (100) : (001) = 88° 45′, (010) : (110) = 60° 3′, and (010) : (011) = 64° 39′. The common habit of the crystals resembles a cube modified by {*hk*0} and {*hkl*} planes (fig. 1). The crystals are aggregated together in such a manner as to suggest the presence of twinning about the plane (001).

The colour of marrite is lead-grey to steel-grey, but the crystals are usually tarnished with iridescent colours. The lustre is metallic and brilliant. The streak is black with a slight tinge of chocolate-colour. The mineral is opaque. No cleavage was observed; the fracture is conchoidal. Hardness, 3.

The name marrite is proposed in honour of Dr. John Edward Marr, F.R.S., of Cambridge.

LIST OF (FORTY) FORMS OBSERVED ON MARRITE.

Symbol.	Indices.	Size of face.	Character of reflection.	Symbol.	Indices.	Size of face.	Character of reflection.
a	{100}	Large	Sharp	$\frac{7}{4}k$	{073}	Narrow	Fair
b	{010}	,,	,,	$2k$	{021}	Large	Good
c	{001}	,,	,,	k	{011}	Fair	Good
$-2h$	{201}	Fair size	Fair	$\frac{2}{3}k$	{023}	Narrow	Fair
$-h$	{101}	Very small	Poor	$\frac{1}{2}k$	{012}	Large	Sharp
$+2h$	{20$\bar{1}$}	Fair size	Sharp	$\frac{1}{3}k$	{013}	Narrow	Fair
$+h$	{10$\bar{1}$}	Very small	Poor	$\frac{1}{5}k$	{015}	,,	,,
$7r$	{170}	Narrow	Broad	$-2q$	{121}	Very small	Faint
$6r$	{160}	,,	,,	$-p$	{111}	Fair	Good
$5r$	{150}	,,	Fair	$-2t$	{212}	Small	Fair
$4r$	{140}	Fair size	Good	$-2u$	{211}	,,	,,
$3r$	{130}	Narrow	Fair	$+3v$	{13$\bar{1}$}	,,	,,
$2r$	{120}	Large	Sharp	$+2q$	{12$\bar{1}$}	,,	,,
$\frac{3}{2}r$	{230}	Fair size	Fair	$+p$	{11$\bar{1}$}	Fair	Good
r	{110}	Large	Sharp	$+2p$	{11$\bar{2}$}	Small	Fair
$\frac{3}{2}s$	{320}	Narrow	Fair	$+2t$	{212}	Fair	Good
$2s$	{210}	,,	,,	$+2u$	{21$\bar{1}$}	,,	,,
$\frac{7}{4}s$	{720}	,,	,,	$+z$	{233}	Small	Fair
$\frac{7}{4}k$	{072}	,,	Good	$+x$	{22$\bar{3}$}	,,	,,
$3k$	{031}	Large	Sharp	$+y$	{23$\bar{1}$}	,,	,,

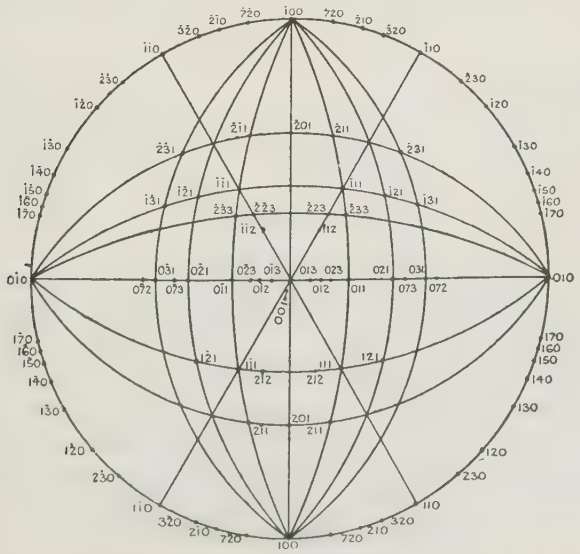


FIG. 2.—Stereographic projection of marrite.

CALCULATED AND MEASURED ANGLES OF MARRITE.

	Calculated.	Measured. I.	Measured. II.		Calculated.	Measured. I.	Measured. II.
Zone [100,001].	° ′	° ′	° ′	Zone [010,203̄].	° ′	° ′	° ′
(100) : (201)	30 58	30 56	30 59	(010) : (233̄)	67 42	67 24	67 30
: (101)	49 50	—	—	: (223̄)	74 19	74 19	—
: (001)	88 45	88 45	88 45	Zone [010,101̄].			
(100) : (201̄)	31 38	31 38	31 38	(010) : (131̄)	42 1	42 0	—
: (101̄)	51 19	—	—	: (121̄)	53 30	53 33	53 31
: (001̄)	91 15	91 15	91 15	: (111̄)	69 42	69 44	69 43
Zone [010,001].				: (212̄)	79 31	79 40	79 35
(010) : (072)	31 5½	31 7	31 8	Zone [010,201̄]			
: (031)	35 8	35 8	35 8	(010) : (231̄)	53 21	53 23	—
: (073)	42 8	42 15	—	: (211̄)	76 3	76 4	76 10
: (021)	46 32½	46 32	46 32	: (201̄)	90 0	90 0	90 0
: (011)	64 39	64 40	64 39	Zone [100,011].			
: (023)	72 28½	72 29	—	(100) : (211)	33 27	33 33	33 32
: (012)	76 40½	76 39	76 40	: (111)	52 42	52 37	52 38
: (013)	81 1½	81 5	—	: (011)	88 53	88 45	88 53
: (015)	84 35	—	84 30	(100) : (211̄)	34 17½	34 17	34 14
: (001)	90 0	90 0	90 0	: (111̄)	54 7	54 5	54 3
Zone [010,100].				: (011̄)	91 7	91 15	91 4
(010) : (170)	13 55½	14 0	—	Zone [001,110].			
: (160)	16 8	16 5	—	(001) : (111)	42 59½	43 2	43 2
: (150)	19 8½	19 6	19 0	: (110)	88 54½	88 58	88 58
: (140)	23 27	23 28	23 30	(001) : (1̄12)	25 35	—	25 47
: (130)	30 3	30 1	—	: (2̄23)	32 38	32 48	32 38
: (120)	40 57	40 57	41 0	: (1̄11)	44 1	44 2	44 1
: (230)	49 6	49 6	49 0	: (1̄10)	91 5½	91 3	91 4
: (110)	60 3	60 3	60 3	Zone [001,120].			
: (320)	68 59	69 0	69 1	(001) : (121)	50 56	50 54	—
: (210)	73 55½	73 56	73 58	: (120)	89 10	89 14	89 11
: (720)	80 39½	—	80 42	(001) : (1̄21)	51 57	51 58	51 56
: (100)	90 0	90 0	90 0	: (1̄20)	90 50	90 46	90 49
Zone [010,201].				Zone [001,210].			
(010) : (211)	76 43	76 17	—	(001) : (212)	40 2	40 6	40 4
: (201)	90 0	90 0	—	: (211)	58 48	58 55	58 45
Zone [010,101].				: (210)	88 48	88 43	88 50
(010 : (121)	54 5½	54 3	—	(001) : (2̄12)	41 4	40 37	41 0
: (111)	70 6	70 6	70 5	: (2̄11)	60 40	60 25	60 39
: (212)	79 44½	79 44	79 43	:(2̄10)	91 12	91 7	91 10
: (101)	90 0	—	90 0				

LENGENBACHITE.

This new mineral occurs in thin blade-shaped crystals, sometimes very thin and curled up like paper; they exhibit a highly perfect cleavage, with splendent lustre, parallel to the large face. One crystal measured 40 mm. in length and 5 mm. in breadth. The common habit is an irregular interlacing of thin plates striated parallel to their length, but frequently I have noticed the union of two or more plates parallel to the cleavage-plane at an angle approximating closely to 60°, on one or both

sides of the long edge of the plate; also a less common aggregation is one similarly arranged, but making an angle approximating closely to 90°. This twinning (?) about a plane at 45° to the long edges of the crystals is also to be seen in sartorite, rathite, and baumhauerite, crystals of which sometimes cross one another at right angles. A third aggregation is that of two long prisms twinned and combined together about a plane bevelling the edge of the long side of the prism; the reflection from the two cleavage planes of the twinned parts is very good, and the angle measured was 28° 37′.

Some of the crystals exhibit a number of fine striae, which traverse the cleavage-planes and bevelled edges at an angle, on the cleavage-plane, of about 58° with the long edge of the plate; such crystals might easily be mistaken for thin crystals of jordanite.

Various crystal fragments were measured to endeavour to discover the crystallographic system. From the best crystal I obtained in the prism-zone, $[CM]$, the angles $CM = 92° 30′$ and $CN = 25° 18′$; for a zone of faces terminating the crystal the angles $Ch = 70° 7′$, $Cg = 81° 32′$, $Cl = 106° 32′$, and $Cm = 121° 0′$; and for other terminal faces not falling into any zone the angles $Cd = 91° 40′$, $Cf = 94° 8′$, $Ca = 60° 4′$. In the prism-zone of another crystal the angles to the cleavage C were 85° 12′, 91° 31′, 96° 33′, 98° 6′, and 117° 10′; and in the prism-zones of other crystals 43° 0′ and 53° 35′, 51° 7′ and 57° 12′. The re-entrant angle, $C\bar{C}$, in the prism-zone of a twinned crystal was 28° 37′. As I have been unable to perceive any plane or axis of symmetry present in the crystal fragments measured, I conclude that the system of lengenbachite is anorthic.

I had hoped that the very thin plates, though opaque to light, might have proved transparent to radiant heat[1], and so help to determine the symmetry, but Dr. A. Hutchinson tells me that he finds that they are absolutely opaque to heat-rays.

The plates are flexible, but not elastic; they are somewhat malleable, make a mark on paper, and are difficult to pulverize. The crystals do not fly asunder when heated, as do the other sulpharsenites of lead from the Binnenthal. The specific gravity of 1·3700 gram. of picked plates was found to be 5·80. Lustre, metallic; colour, steel-grey, often with an iridescent tarnish. Opaque. Streak, black, with a chocolate tinge.

A preliminary chemical examination, kindly made by Dr. A. Hutchinson, proves the mineral to be essentially a sulpharsenite of lead with small amounts of silver, copper, and antimony.

[1] See Hutchinson, Min. Mag., 1903, vol. xiii, p. 342.

For the new mineral described above I propose the name lengenbachite [1], after the Lengenbach, a tributary stream in the Binnenthal, which flows through the dolomite quarry where the crystals were discovered in July, 1904.

Bowmanite.

System: rhombohedral. (111) : (100) = 53° 50′. $a : c = 1 : 1{\cdot}1847$. This element was calculated from (100) : (010) = 88° 43½′, measured on a crystal giving very sharp reflections; another crystal with fairly sharp reflections gave (100) : (111) = 53° 50′.

Forms observed: $o\{111\}$, $r\{100\}$, $f\{\bar{1}11\}$. The common habit is a rosette-like aggregation of a number of thin plates with curved surfaces: the individual crystals are usually six-sided plates parallel to $\{111\}$, and are bounded at the edges by narrow faces of $\{100\}$ and $\{\bar{1}11\}$. Sometimes the crystals resemble octahedra, $\{111\}$ and $\{100\}$ being equally developed: the faces of the form $\{\bar{1}11\}$ are always small, and deeply striated parallel to their intersections with (111).

Colour, honey-yellow. Lustre, brilliant, and vitreous to resinous in character. Streak, white. There is a perfect cleavage parallel to (111)[2]. Hardness, 4½. Specific gravity, 3·2. Transparent; optically uniaxial and positive. Occurs on and among crystals of dolomite in the Lengenbach quarry.

The name bowmanite I have given to this new mineral in honour of Mr. Herbert Lister Bowman, M.A., Demonstrator in Mineralogy in the University of Oxford.

The above description is based on a few small crystals obtained in the summer of 1904; but I have, during the last three years, collected a few small rounded honey-yellow crystals, the faces of which were too irregular and curved to admit of accurate measurement.

The small amount of available material has been handed over to Mr. Bowman for examination. He reports that in some of its characters the new mineral resembles hamlinite, from which, however, it differs

[1] A note on lengenbachite, marrite, and bowmanite was read at the Cambridge meeting of the British Association in August, 1904, and these names were first published in 'Nature' on December 1, 1904 (vol. lxxi, p. 118).

Amongst a series of Binnenthal minerals exhibited at a meeting of the Vienna Mineralogical Society on November 7, 1904, were specimens of a new and undescribed species to which the name jentschite was applied. So far as can be judged from the brief description of the exhibits, as reported in Tschermak's Mitteilungen (1904, vol. xxiii, p. 551), jentschite would appear to be identical with the mineral described above under the name lengenbachite. In the same place brief mention is also made of some new minerals under the names hutchinsonite and trechmannite.

[2] Not (100), as stated in 'Nature,' 1904, vol. lxxi, p. 118.

in composition, being essentially a phosphate of lime and alumina, with small amounts of iron, water, and possibly magnesia.

He finds, further, that the crystals are pseudosymmetric, and show, through thin plates cleaved parallel to the basal plane, a division into six biaxial sectors, in which the acute bisectrix is normal to the surface, the axial plane nearly at right angles to the adjacent edge of the hexagonal plate, and the birefringence positive and rather strong. The axial angle varies, in some cases reaching a value $2E = 50°$, while some of the crystals are uniformly uniaxial, without sectors.

It is hoped that more material will soon be found, so that the composition and characters of the mineral may be more completely determined.

APPENDIX.

Blende with metallic lustre, from the Binnenthal.

These highly modified and twinned crystals of tetrahedral habit were found in 1904 in the slate-coloured dolomite of the Lengenbach quarry. They are especially interesting on account of the very thin and highly brilliant, metallic [1], lead-grey coating by which they are enveloped; this surface film becomes dull when exposed to the light, and disappears rapidly in the presence of hydrochloric acid. The crystals might easily be mistaken for galena or tennantite.

According to Becke [2], the largely developed octant of the Lengenbach blende is $\{1\bar{1}1\}$, and this orientation of the crystals is here adopted. With the exception of a small tetrahedral face (111), all the forms on these crystals lie in the negative octants.

The following table of calculated and measured angles between the faces of the three crystals (I, II, III) contains five new forms marked *.

		Measured.		
	Calculated.	I.	II.	III.
(100) : (6$\bar{1}$1)*	13°16′	13°14′	13°16′	—
: (4$\bar{1}$1)	19 28	19 26	—	—
: (2$\bar{1}$1)	35 16	35 16	35 16	35°16′
: (7$\bar{4}$4)	38 56½	—	39 0	—
: (11.7.7)*	41 59	41 59	42 0	41 58
: (7$\bar{5}$5)*	45 17	45 14	—	45 17
: (13.$\bar{1}$0.10)*	47 24½	—	—	47 17
: (5$\bar{4}$4)*	48 31½	48 28	48 30	—
: (1$\bar{1}$1)	54 44	54 44	54 44	54 44
: (110)	90 0	—	90 0	—

[1] Crystals of blende with metallic lustre have been described by Professor Miers, Min. Mag., 1899, vol. xii, p. 111. [2] Min. petr. Mitt. (Tschermak), 1883, vol. v, p. 507.

Seligmannite [1].

In October, 1904, some comparatively large (measuring 2·5 × 2 × 1 mm.) black, much twinned crystals of this very rare mineral were found. They are deposited on large crystals of dufrenoysite, and also on baumhauerite. Mingled with the seligmannite, and partially coating the baumhauerite, are a number of very fine needles of a lead-grey colour, the nature of which I have as yet been unable to determine.

Montreux Club,
Territet, Switzerland.

[1] Cf. Min. Mag., 1903, vol. xiii, p. 336.

An improved form of Refractometer.

By G. F. Herbert Smith, M.A., F.G.S.
Assistant in the Mineral Department of the British Museum.

[Read June 7 and November 15, 1904.]

THE first form of refractometer, in which a reference-scale was substituted for the rotational parts and graduated circles of the more complex instruments, was designed in 1885 by Professor E. Bertrand[1], who at the same time was the first to suggest the employment of a hemisphere of dense glass in place of the prism and cylinder previously used. The original instrument and others on the same principle which have hitherto been constructed do not give satisfactory results, because no attempt has been made to compensate for the curvature of the focal surface of the hemisphere, and the determinations obtained are, therefore, far from trustworthy. In the refractometer described in this paper a corrective lens is placed in the path of the rays emerging from the hemisphere, and the field thus produced is rendered very nearly plane.

For a particular substance in contact with the plane surface of the hemisphere the angle of total-reflection is $\sin^{-1}\frac{\mu}{\mu_0}$, where μ and μ_0 are the refractive indices of the substance and the glass respectively. At any point on the plane the limiting rays of total-reflection form a cone, the axis of which is normal to the plane and the vertical angle double of that of total-reflection. If the effects of spherical and chromatic aberrations be neglected, the rays parallel to any particular ray of the cone come to focus at a point which lies on the ray passing through the centre of the spherical surface at a distance $\frac{\mu}{\mu-1}.r$ from the centre, where r is the radius of the hemisphere. The focal surface, therefore, for all angles of total-reflection is part of a sphere concentric with the glass hemisphere and of radius $\frac{\mu}{\mu-1}.r$. The rays for any particular angle of total-reflection come to focus on a small circle, forming the intersection of the sphere with the cone mentioned above. Since it is impossible for

[1] Bull. Soc. Min. France, 1885, vol. viii, pp. 375–377.

a plane to coincide with a spherical surface, accurate readings are out of the question owing to the bad definition of the edge of the shadow and the uncertainty of its true position owing to the effects of parallax.

It is necessary, therefore, to compensate in some way for the curvature of the focal field. After a few experiments the author found that adequate compensation was obtained by the interposition of a convex lens of suitable focal length in the path of the rays emerging from the hemisphere. The problem is, indeed, to bring light which is parallel within the glass to focus in a flat field, and is the same as the construction of a telescope in which the field-lens of the objective is a hemisphere of dense glass, the plane surface being turned outwards, and in which the angular width of the field is about 30°. The simplest and

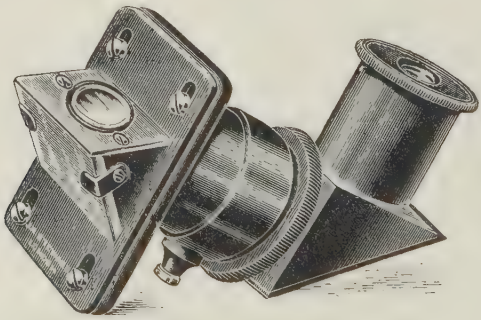


Fig. 1.—Refractometer (actual size).

most convenient method of testing the efficiency of any corrective lens is to employ it in conjunction with the hemisphere as the objective of such a telescope. The author found that, if the hemisphere, 10 mm. in diameter, be composed of glass, the refractive index of which for the D lines is 1·7938, a convex lens of crown glass and focal length 13 mm., placed with the surface of greater curvature almost in contact with the hemisphere, gave satisfactory results, and that, when this combination is employed as a total-reflectometer, the edges separating the light and dark fields are sharply defined throughout the whole of the effective range of the instrument. For reasons stated above the edges appear as circular arcs. If, however, the hemisphere and convex lens be replaced by a semi-cylinder and a cylindrical lens respectively, the sections of the latter pair perpendicular to their geometrical axes being identical with the central sections of the former pair, the edges become straight

lines; it is important that the axes of the cylinders should be truly parallel.

The illustration (fig. 1) shows the construction of the instrument. The hemisphere of dense glass, the refractive index of which is 1·7938, is firmly embedded in a thin, brass plate, which is attached by screws to two shoulders rigidly connected to a vertical brass plate. The hemisphere is inclined in such a position that the angle between the perpendicular to its plane surface and the axis of the tube of the instrument is about 64°, and thus the centre of the field corresponds to a refractive index of 1·61. The plate of ground-glass is equally inclined to the vertical plate, but in the converse sense. Four screws passing through slots in the vertical plate connect it with a similar plate terminating the tube, and thus an adjustment of the centre of the plane surface of the hemisphere is provided with regard to the axis of the tube. At the end of this tube is placed the corrective lens, the surface of greater curvature being almost in contact with the hemisphere and its optic axis coinciding with the axis of the tube. The clamp at the other end grips an inner tube carrying at its inner extremity a thin, glass plate on which a scale, figured at every tenth division (fig. 2), has been photographed. Inside the inner tube slides a positive eye-piece, in which a totally-reflecting prism is interposed between the two lenses for greater convenience in taking observations.

Fig. 2.—Scale with shadow-edges.

The effective range of the instrument is from about 1·40 to 1·76. Each interval on the scale corresponds to a difference of refractive index varying from 0·007 in the higher to 0·015 in the lower indices. If sodium-light be the source of illumination the edge separating the light and dark fields appears as a delicately traced line and is so well defined that a practised eye can estimate the tenths of divisions, and thus measurements may be carried to one or two units in the third place of decimals. The scale is calibrated for this light by means of observations made on a few substances of known refractive power. If white light be used the edge is no longer a line but a spectrum, in which case the position corresponding to the yellow portion should be noted. The value thus obtained will be accurate to units in the second place of decimals at least, and will be sufficient for most determinative purposes. The width of the spectrum measures the amount of chromatic dispersion

displayed by the substance under examination. With this instrument accurate measurements may be made of the refractive power of fragments so small as 1 mm. in diameter.

The refractometer has been constructed by Mr. J. H. Steward, the well-known optician of London, whose keen interest in the development of the instrument and zealous assistance in the preliminary experimental work it affords the author much pleasure to acknowledge.

On some new forms of Quartz-wedge and their uses.

By John W. Evans, LL.B., D.Sc., F.G.S.

Mineralogist to the Scientific and Technical Department of the Imperial Institute.

[Read November 15, 1904.]

THE determination of the amount and sign of the relative retardation of the wave-fronts of the two rays, into which a plane-polarized ray of light is resolved in passing through an anisotropic crystal, furnishes us with the readiest means of identifying transparent minerals occurring in thin sections or as minute fragments without definite crystalline form. In sections which are of practically the same thickness the individual crystals of each mineral show a certain range of colours resulting from the interference of the rays after resolution parallel to the principal plane of the analyser, and these colours are usually sufficient, with the help of other characters, for the identification of the mineral species. But when the thickness of the micro-sections varies considerably, or we are dealing with small grains from river sand or fragments resulting from the crushing of a rock, the problem is less simple, and quantitative determinations are required.

Every ray passing through a substance suffers retardation, that is to say, travels a less distance than it would traverse in the same time in vacuo. The retardation r_1 suffered by a ray of light in traversing a unit of distance in any isotropic substance is $\frac{v}{v_1} - 1$, where v is the velocity in vacuo and v_1 the velocity in the substance, for $\frac{v}{v_1}$ is the distance the light would have gone in vacuo in the same time as it occupied in traversing one unit of distance in the substance.

But $\frac{v}{v_1} = \frac{1}{u_1} = \mu_1$, where u_1 is the velocity in the substance, taking the velocity in vacuo as unity, and μ_1 is the index of refraction in the substance. Accordingly, we have

$$r_1 = \frac{v}{v_1} - 1 = \frac{1}{u_1} - 1 = \mu_1 - 1.$$

The quantity r_1, the retardation in a unit of length, may be termed the index of retardation.

In the case of light, travelling in a given direction, entering an anisotropic substance it is resolved in general into two rays propagated at different rates. If the wave-fronts of these rays have velocities v_1 and v_2, or, taking the velocity in vacuo as unity, u_1 and u_2, and their indices of refraction are μ_1 and μ_2, and indices of retardation r_1 and r_2,

$$r_1 = \frac{v}{v_1} - 1 = \frac{1}{u_1} - 1 = \mu_1 - 1,$$

and

$$r_2 = \frac{v}{v_2} \quad 1 = \frac{1}{u_2} - 1 = \mu_2 - 1.$$

If d be the difference in the retardation of the two wave-fronts in a unit of length parallel to the wave-normals [1],

$$d = r_1 - r_2 = \frac{1}{u_1} - \frac{1}{u_2} = \mu_1 - \mu_2.$$

The quantity d is usually known as the strength of double refraction, or birefringence, but it is better described as the relative retardation in a unit of length, or the index of relative retardation.

If, instead of a unit length, a distance l be traversed parallel to the wave-normals in the anisotropic medium and k be the total relative retardation of the two wave-fronts in passing through that distance, we have

$$k = ld.$$

For instance, if a thin section of quartz be cut parallel to the axis, the index of relative retardation (birefringence) of light traversing it approximately at right angles will be 0·0091 (for sodium-light): then if the thickness of the section be 0·023 mm. we have

$$k = 0{\cdot}023 \times 0{\cdot}0091 = 0{\cdot}000209.$$

It is, however, usual to take as the unit of relative retardation a micromillimetre, or millionth part of a millimetre, as by so doing numerous decimal places are avoided. This unit is, however, too small for measuring the thickness of thin plates and small crystals, and I have found it convenient to take as unit of thickness a thousandth part of a millimetre, viz. a thousand micromillimetres. The relative retardation in micromillimetres in traversing this distance will be a thousand times that in traversing a micromillimetre, that is, a thousand times the absolute index of relative retardation or birefringence; and it is free from the disadvantage of being a small fraction of unity.

[1] Strictly speaking the wave-fronts will be parallel only if the ray meets a plane surfaceof the anisotropic medium at right angles.

If then

K = relative retardation in micromillimetres,

L = thickness in thousandths of a millimetre,

D = relative retardation in micromillimetres in traversing one thousandth part of a millimetre

$$= 1000\,d = 1000\left(\frac{1}{u_1} - \frac{1}{u_2}\right) = 1000\,(\mu_1 - \mu_2),$$

we have

$$K = LD.$$

D may be considered a working index of relative retardation one thousand times the absolute index. The calculation given above then becomes

$$K = 23 \times 9{\cdot}1 = 209.$$

To ascertain the index of relative retardation in any particular direction in a crystal it is, therefore, sufficient to know the thickness of the crystal in the direction in question and the relative retardation that takes place in that distance [1]. The latter is approximately determined by reference to a scale of Newton's colours, either in a coloured plate or expressed in words. In neither case are very satisfactory results obtained, especially when the colours become fainter or entirely disappear as the relative retardation increases. By the use, however, of the quartz-wedge inserted in the position of compensation [2] it is possible, when the relative retardation is not too great, to determine to which of the orders in Newton's scale the colour belongs.

To secure more exact determinations of the relative retardation various means have been employed, among which may be mentioned the bifractometer, the Babinet compensator, and the twin-compensator. These are, however, complicated pieces of apparatus, designed rather for the determination of physical constants than for the identification of small mineral particles.

In the laboratory of the Scientific and Technical Department of the Imperial Institute it is frequently necessary to recognize small sand-grains and fragments of crushed rock or veinstuff, and for this purpose a quartz-wedge, that has been made under my directions by Messrs. R. & J. Beck, Ltd., has proved very useful.

Its angle is much larger than that of wedges ordinarily in use, the maximum thickness being as much as a millimetre and a half. It is

[1] See Mallard, Traité de Cristallographie, Paris, 1884, vol. ii, p. 399.

[2] For this purpose it is best placed in the focus of the eye-piece, a microscope being employed in which the analyser is above the eye piece.

graduated so as to show the relative retardation of light passing through it at different points, the relative retardation at two adjoining divisions differing by a thousand micromillimetres. The divisions were fixed by ascertaining with a micrometer-screw the points at which the thickness amounted to multiples of $\frac{1000}{9{\cdot}1}$ thousandths of a millimetre [1]. I calibrated the wedge by placing it in sodium-light, first between crossed nicols, when the dark bands gave the points where the relative retardation amounted to an even number of semi-wave lengths, and then between parallel nicols, when similar bands gave the points where it amounted to an odd number of semi-wave lengths. The average difference of relative retardation between adjacent lines was thus calculated to be 999·6 micromillimetres.

With this wedge relative retardations up to 14,000 units (about twenty-eight 'orders' of colours) could be observed. A still thicker wedge is, however, sometimes needed.

In determining the index of relative retardation in small fragments they are immersed in a liquid of sufficiently high index of refraction to render them fairly transparent. The thickness is then determined by using a high power and focusing with the fine adjustment, which should be graduated in thousandths of a millimetre, first on an edge or crack on the top of the fragment and then on a scratch in the glass-slip on which it lies. This apparent thickness multiplied by the index of refraction of the liquid gives the real thickness of the fragment [2].

The relative retardation of light traversing the fragment is measured by inserting the wedge in the position of compensation till the dark band representing complete compensation is reached. The relative retardation is then read off directly from the wedge, amounts of less than a thousand micromillimetres being estimated from the position between the two nearest graduations.

If the surface of the fragment is irregular, coloured bands are seen, which are mainly due to the variation in the thickness of the fragment.

[1] The graduations of the 'birefractometer' represent the thickness in decimal parts of a millimetre, not the relative retardation.

[2] The focus is best determined by using a strong monochromatic light passing through a small aperture six inches at least from the mirror of the microscope. Interference rings are formed unless the focus is very exact (see Lévy and Lacroix, 'Les Minéraux des Roches,' Paris, 1888, p. 60). The thickness may also be measured through the mineral and multiplied by its approximate index of refraction as estimated by Becke's method. This usually gives a sufficiently approximate value for the index of relative retardation to enable the mineral to be identified.

Some particular point in the crystal must accordingly be chosen for the determination both of the thickness and relative retardation.

If the index of relative retardation of the crystal is very high the bands are sometimes so narrow that it is difficult to distinguish the colours, and these are often appreciably modified by the variations in the index for different parts of the spectrum. An approximate result can then be obtained by observing the reading on the wedge when the bands begin to be visible in the part of the fragment selected for the observation, and the reading when they disappear; the mean of these readings will give with close approximation the relative retardation.

If a high power be used in determining the relative retardation the cone of light should be narrowed either by lowering the condenser or by the use of a diaphragm, so that the colours or bands may be more clearly visible.

For the determination of the index of relative retardation of minerals in thin sections, which show colours corresponding to comparatively low relative retardation, I find it convenient to use a double quartz-wedge[1], which I have also had made by Messrs. R. & J. Beck, Ltd., for the Imperial Institute. It consists of two quartz-wedges placed close together, side by side. One is cut in the usual manner with its length parallel to the vertical axis of the crystal, the other with its breadth parallel to the same direction, so that when placed with their lengths parallel they have their axes at right angles and therefore extinguish simultaneously between crossed nicols. They are ground down together to the same slope, and when placed obliquely between crossed or parallel nicols they show exactly the same bands of colour, which pass continuously across both wedges. If now a crystal-plate is also placed in the position of extinction between the crossed or parallel nicols, the two wedges continue to show the same colours; but if, by the rotation of the crystal or of the nicols and double wedge together, the directions of extinction of the crystal are parallel to those of the double quartz-wedge and make an angle of 45° with the nicols, one of the wedges will show a black band indicating the position of compensation, while the second will show colours corresponding to increased relative retardation. It is evident that the colour, which on the latter wedge is opposite the centre of the dark band of the former, denotes a relative retardation exactly double that of the crystal-plate alone, and thus a more accurate determination of the relative retardation of the plate may be made. Either the relative

[1] I find that somewhat the same principle has been applied in a different manner in the twin-compensator.

retardation corresponding to the colour opposite to the centre of the dark band should be divided by two; or, better, the colour on one wedge opposite to a sensitive tint (*teinte sensible*) on the other should be noted, and the difference of the relative retardations corresponding to these colours, or the sum of those relative retardations if one of the colours is between the dark band and the thin end of the wedge, should be halved in like manner. Additional accuracy can be obtained by making several similar observations with crossed and parallel nicols. With low relative retardations parallel nicols usually show more distinctive tints.

The double wedge is also more convenient than the single wedge for determining the sign of a direction of extinction in a mineral in a thin section, for a comparison of the two sides tells clearly and at once which shows compensation and which addition.

It can also be used as a stauroscope; for, if a crystal-plate is rotated between crossed or parallel nicols with the double wedge at 45° to them, or the nicols and wedge are rotated together, the crystal being stationary, the position of extinction is known by the exact correspondence of the bands on the two wedges.

It is scarcely necessary to add that, as pointed out by Mallard and by Lévy and Lacroix[1], the thickness of a section may be determined by observing which of a number of individuals of some known mineral has the colour representing the greatest amount of relative retardation. It may then be assumed that this individual is cut so that the velocities of the two wave-fronts of light propagated transversely to the section are approximately the same as the greatest and least velocities in the mineral, and that the index of relative retardation at right angles to the section is nearly equal to the maximum index of relative retardation in the crystal; the latter being the difference between the greatest and least retardations, or, what is the same thing, the difference between the greatest and least indices of refraction—or a thousand times this amount if the working index of relative retardation, which I have suggested, is employed in place of the absolute index.

We can now calculate the thickness of the section at once from the formula $K = LD$, where K is the observed relative retardation in millimetres, $D = 1000\,(\gamma - \alpha) = 1000\left(\frac{1}{u_\gamma} - \frac{1}{u_\alpha}\right)$, and L is the thickness in thousandth parts of a millimetre.

[1] loc. cit.

Note on some new localities for Gyrolite and Tobermorite.

By James Currie, M.A., F.R.S.E.

[Read November 15, 1904.]

SINCE the mineral gyrolite was described and analysed by Anderson from Storr in Skye in 1851, it has been recorded from a considerable number of other places in that island. The writer observed it at the mouth of the burn called Allt Mòr, between Loch Brittle and Loch Eynort, and has now to record it from Rudha nan Clach at the mouth of Loch Bracadale, which brings the number of localities at present known in Skye up to fourteen. In fact, the mineral may be said to occur all along the south-western shore, all along the eastern escarpment, and at the more isolated localities of Lyndale and Portree. Similarly, it occurs in the other trap islands—the Treshnish group, Mull, Muck[1], Eigg, Canna, and Sanday, upon the last of which it has been observed by the writer at Stac nan Faoilean. In all, we have now some thirty localities in the Western Islands of Scotland; so that, although very seldom found in fine specimens, gyrolite may be said to be a characteristic mineral of the denser igneous rocks of the Hebrides.

It has not hitherto been recorded[2] from the mainland of Scotland; but the writer recently observed it in Argyllshire. The line of trap cliff, which stretches south from Ardtornish Bay in Morvern until it is cut off by the fault of the Dearg Allt, surmounts a steep talus overgrown with grass and clothed with bracken and low wood. There are few screes and the rock is much weathered and moss-covered. It is not markedly amygdaloidal, but occasionally analcime upon mesolite may be observed. In the harder and more basaltic rock the steam cavities are small and rare. When they do occur they are generally filled with gyrolite.

Very rarely the druses of the Ardtornish basalt are filled with reddish-white, massive tobermorite, apparently upon mesolite. The species tobermorite has also not been hitherto observed upon the mainland. It has been recorded by Heddle[3] from Tobermory and Bloody Bay in Mull

[1] M. F. Heddle, 'The Mineralogy of Scotland,' 1901, vol. ii, p. 98.

[2] A reported occurrence in Stirlingshire was shown by Lacroix to refer probably to thomsonite (Bull. Soc. franç. Min., 1887, vol. x, p. 148).

[3] 'The Mineralogy of Scotland,' 1901, vol. ii, p. 83.

and from Dunvegan in Skye. Sgùrr nam Boc in the latter island should also have been given [1]. On the other hand tobermorite with analcime is mentioned in 'The Mineralogy of Scotland' as associated with the gyrolite of Beinn na Croise in Mull by an error in the transcription of the MS., which has transferred these minerals from the locality immediately following. They really belong to Bloody Bay [2].

The only other mineral in the rock at Ardtornish is yellowish-green olivine in small nodules of 3 to 4 mm. in diameter.

In every case, so far as the writer knows, the Scottish gyrolites occupy the infrequent druses of dense Tertiary basalts, and are generally solitary. The only common associate is the closely allied mineral apophyllite.

The mode of occurrence in Scotland does not lend any support to Professor How's supposition that gyrolite owes its origin to the decomposition of apophyllite. In fact when they occur together the apophyllite in Scotland seems invariably to overlie the gyrolite, as it does in California, so that in these cases it would be more reasonable to derive the former mineral from the latter. But in specimens freshly extracted from the rock both minerals appear perfectly unaltered, and there does not seem to be any ground whatever for the supposition that either is formed at the expense of the other. It is curious that if How's statement [3] be correct, the order of deposition in Nova Scotia is the reverse of that observed in Scotland, while in California we again have the gyrolite as the older mineral.

Gyrolite was some time ago recorded by Professor Heddle from the Færöes, his locality being Kodlen in Osterö. It has been observed by the writer at three other localities, all of them in the island of Stromöe. These are the shore of Leinum Vatn (sometimes called Store Vatn); Vestmannhavn; and Sundelaget, at the narrowest part of the strait between the two principal islands.

At the last-named locality the gyrolite, here associated with small superimposed crystals of apophyllite in the combination *a c*, sometimes overlies a massive, white mineral with a minutely mamillated surface, which, so far as can be judged without analysis, is identical with tobermorite.

Professor Heddle [4] further identified with gyrolite the 'micaceous

[1] See Heddle, Trans. Geol. Soc. Glasgow, 1892, vol. ix, p. 254.
[2] Cf. 'The Mineralogy of Scotland,' 1901, vol. ii, p. 92.
[3] Edinburgh N. Phil. Journ., 1861, vol. xiv, p. 117.
[4] 'The Mineralogy of Scotland,' 1901, vol. ii, p. 79.

zeolite' of Giesecke from Niakornak, which of course is not upon Disco Island as stated by Haidinger, but upon the south shore of Umanak Fjord in Greenland. Giesecke in his diary[1] says that the 'faserigen Mesotyp . . . geht oft ins krummblätterige über, ist schiefrig, hat einen starken Perlenmutter-, oft beinahe metallischen (Silber-) Glanz, und braust etwas mit Salpetersäure [probably from calcite present as an impurity]. Seine Krystallisation scheint die sechsseitige Tafel zu sein.' Elsewhere he calls this mineral 'Glimmerzeolith,' and at Tupausarsuit[2] connects it with the accompanying apophyllite. Both minerals also occur at Tarajungitsok in Disco Fjord[3]. Perhaps gyrolite is also indicated by the 'massive apophyllite' and 'pearl-white radiated mesole' of Akkiarut[4]. Although they are really very distinct in appearance, it is by no means always easy to decide whether faröelite or gyrolite is intended by the 'mesole' of some of the older writers.

It is interesting to note that Sir Charles Giesecke records as accompanying the apophyllite and gyrolite of Tupausarsuit a 'pale red massive zeolite[5],' which we may probably infer to be tobermorite.

[1] F. Johnstrup, 'Gieseckes mineralogiske Rejse i Grønland,' Kjøbenhavn, 1878, p. 245.

[2] loc. cit., p. 255.

[3] loc. cit., p. 329.

[4] C. L. Giesecke, 'A descriptive catalogue of a . . . collection of Minerals in the Museum of the Royal Dublin Society,' Dublin, 1832, pp. 54, 55.

[5] loc. cit. (Diary), p. 255.

Note on the occurrence of Brookite in the Cleveland ironstone.

By C. R. Lindsey, B.Sc.

[Read November 15, 1904.]

THE references to the occurrence of the titanium dioxide minerals as rock constituents have been so recently summarized in the 'Mineralogical Magazine[1]' that it is unnecessary to repeat them, except to refer again to Mr. J. J. H. Teall's record of anatase in the Cleveland ironstone[2].

Wishing to procure some of these crystals, a pound of ore from the Main Seam at Upleatham mines was treated by the usual processes of solution, washing by decantation, and separation by heavy solution. The residue obtained was equal to 0·16 per cent. of the material taken, and consisted mainly of anatase, mostly in sharply developed pyramidal crystals, with some pyrites in nodular concretions, possibly in replacement of some of the oolitic grains, together with other minerals of derived origin, among which rutile and tourmaline were the most prominent.

But, most interesting, were a considerable number of crystals of brookite. This occurred in two forms:—

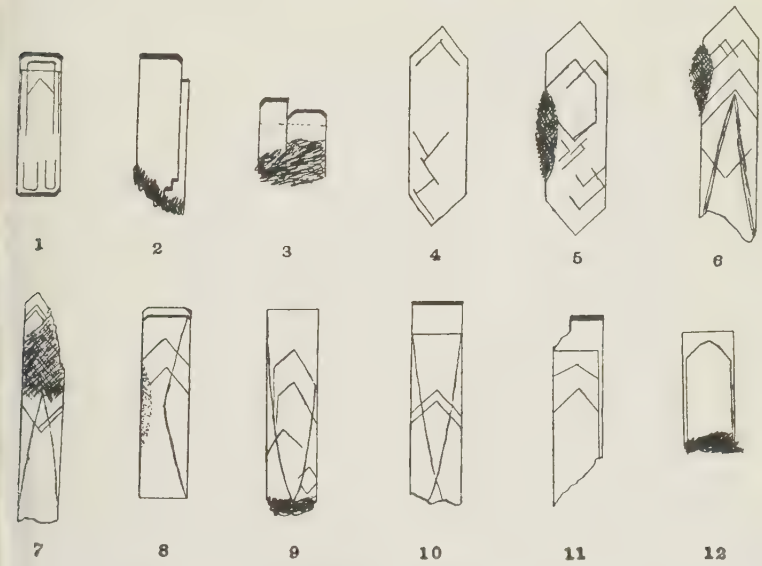
1. Thick, tabular crystals of deep reddish-brown colour, averaging about one-eighth of a millimetre in length by about one-fourth of that amount in breadth, though they sink to much smaller dimensions. They are occasionally doubly terminated, but usually show one end only with crystal-faces (figs. 1, 2, 3), the other end being broken off, or still attached to the material from which the crystals appear to have originated. In convergent polarized light the crystals well show the characteristic crossing of the optic axial planes for blue and red light. The absorption for light rays vibrating across the crystals is distinctly less than for those vibrating parallel to the length of the crystals.

2. The other habit in which the crystals occur is in extremely thin plates of the forms shown in figs. 4, 5, 6, 7. The external boundaries, as well as the lines marking the edges of the parallel growths, are very sharply

[1] J. B. Scrivenor, 1903, vol. xiii, p. 348.

[2] 'British Petrography,' 1888, plate 44, fig. 6, but not referred to in the text. The occurrence of anatase in the Cleveland ironstone was earlier noted by Mr. Allan B. Dick, and the crystals were measured by Professor W. H. Miller ('The iron ores of Great Britain,' Mem. Geol. Survey, 1856, p. 95).

defined. A few crystals are doubly terminated, but mostly they show only one termination, the edges of which meet at an acute angle; this angle has been measured in numerous cases, giving, e.g., $79\frac{1}{2}°$, 80°, $81\frac{1}{2}°$, 81°, 82°, 82°, 81°, so that, allowing for the fact that the crystals may not lie quite perpendicularly to the direction of vision, the angle appears



Crystals of brookite isolated from the Cleveland ironstone.

Fig. 1. Size of crystal: 0·100 × 0·025 mm. The central area is almost opaque.
Fig. 2. Size: 0·125 × 0·035 mm. Colour, deep reddish-brown.
Fig. 3. Crystal with lighter coloured extremity (above the dotted line).
Fig. 4. Size: 0·125 × 0·035 mm. Fig. 5. Size: 0·135 × 0·033 mm.
Fig. 9. Size: 0·245 × 0·042 mm. Fig. 10. Size: 0·108 × 0·025 mm.

(The slides from which these figures were drawn have been deposited in the mineral collection of the British Museum.)

be about 82°. One crystal showed an obtuse termination of about 119° (fig. 11), while another showed one bounded by both forms in combination (fig. 12). The termination of 82° corresponds approximately with {065} or {*h*65}, and that of 119° with {035} or {*h*35}, but none of these are given in any recorded list of forms of brookite, though one of Zerrach's figures[1] seems to have an angle identical with the acute one here mentioned. They polarize in bright colours, sometimes as low as

[1] The middle figure on p. 190 of Rosenbusch-Iddings, 'Microscopical Physiography of the Rock-making Minerals,' first edition, 1888.

those of the second order, but usually in the third and upwards; compensation takes place when the quartz-wedge is parallel to the length of the crystal. Pleochroism is slight, but distinct, the colour being reddish-brown for vibrations parallel to the length of the crystals, and yellowish-brown in the direction at right angles. There is frequently a darker core, like a rather lengthened 'hour-glass' (figs. 6–10); and the end is often of lighter colour than the rest of the crystal (fig. 3), even when this is not caused by differing thickness.

So far, I have been unable to obtain, with crystals of the second habit, a quite satisfactory figure in convergent polarized light, the nearest approach being a division of the field into indistinct areas of blue and red in their proper positions. But as to the identity of the two kinds of crystals I think there can be no doubt, for not only do these thinner crystals show all the other properties of brookite, but crystals occur which combine the forms of both, i. e., they have the rectangular termination of the one kind overlaid in parallel growth by the pointed form of the other (figs. 1 and 8–12).

In the hope that a fortunate chance might show the relation of the brookite to the anatase, three thin sections of the ironstone were prepared, but they yielded only negative results.

It may be mentioned that the now worked-out magnetite ore of Rosedale, in Yorkshire, yielded no brookite; that here the anatase occurred almost wholly in tabular crystals (parallel to the basal plane); and that, as in the other case, rutile occurred as a detrital constituent both in simple crystals and in twins.

The Construction of Crystallographic Projections.

By Harold Hilton, M.A.
Fellow of Magdalen College, Oxford.

[Communicated by Professor Miers, and read November 15, 1904.]

§ 1. It is proposed in this paper to describe some simple graphical constructions of theoretical or practical interest. They may be easily performed with ruler and compasses, though the stereographic and gnomonic nets[1] will often save labour. To economize space the proofs of the constructions are left to the reader.

§ 2. First take the case of the gnomonic projection. Given the projections A, B, C, Q (fig. 1) of the poles of the faces (100), (010), (001), (111); find the projection of the pole of any other face (hkl).

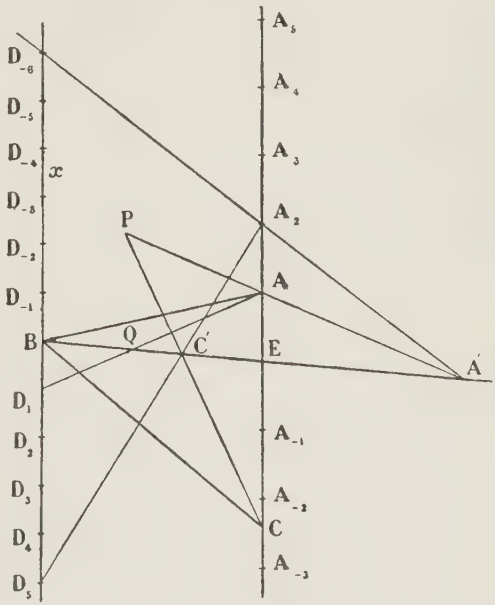


Fig. 1.

Through B draw a line x parallel to AC. Let AQ meet x in D_1, and let BQ meet CA in E. Divide x into equal intervals . . ., $D_{-2}D_{-1}$, $D_{-1}B$, BD_1, D_1D_2, D_2D_3, . . . and CA into equal intervals . . ., $A_{-2}A_{-1}$, $A_{-1}E$, EA, AA_2, A_2A_3, ... Plot the intersections A', C' of BE with A_kD_l, A_kD_h respectively, and the intersection P of AA', CC' (A_1 coincides with A and D_0 with B). P is the point required; for it may readily be shown that the triliteral coordinates of P are (h, k, l), if the coordinates of Q are $(1, 1, 1)$[2]. In the diagram, P is the projection of the pole of $(52\bar{6})$.

[1] See Zeits. Kryst. Min., 1902, vol. xxxvi, p. 14; Min. Mag., 1904, vol. xiv, p. 18.

[2] See p. 104.

The construction holds if h or $l=0$, but not if $k=0$. If $k=0$, we may draw a line through C parallel to AB and proceed similarly; or we may find the projection R of the pole of $(hk'l)$, where $k' \neq 0$, and produce BR to cut CA in the required point.

If Q were the projection of the pole of (uvw) instead of (111), we should take A_{vwk} instead of A_k, D_{uvl} instead of D_l, and D_{vwh} instead of D_h.

More generally, if A, B, C, Q are the projections of the poles of $(h_1k_1l_1)$, $(h_2k_2l_2)$, $(h_3k_3l_3)$, $(h_4k_4l_4)$ instead of (100), (010), (001), (111), we replace h, k, l respectively by $M_2M_3\mu_1$, $M_3M_1\mu_2$, $M_1M_2\mu_3$; where M_1, M_2, M_3 are the cofactors of m_1, m_2, m_3 in the determinant $[h_1k_2l_3m_4]$, and μ_1, μ_2, μ_3 are the cofactors of m_1, m_2, m_3 in the determinant $[hk_1l_2m_3]$.

§ 3. Again, joining the points A, B, C, Q in every possible way we obtain the projections of zones meeting in points which are the projections of poles of crystal-faces. Joining these points we get the projections of more zones which meet in the projections of more poles; and, proceeding in this way, we get the projection of every possible pole. However, except for the poles of faces with very simple indices, this process is more tedious than the method of § 2.

§ 4. Suppose we wish to find the angle between two faces the projections of whose poles are P and Q.

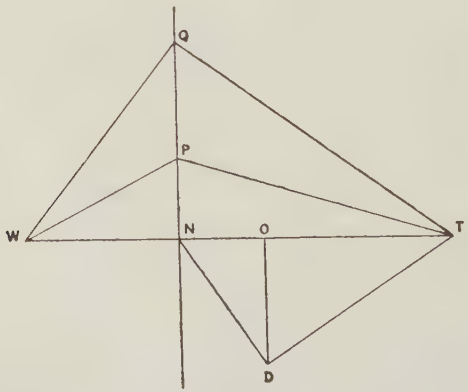


Fig. 2.

Let O (fig. 2) be the centre of the projection and r the radius of the sphere of reference. Draw ON perpendicular to PQ, and draw OD perpendicular to ON and equal to r. Take W on ON such that $NW=ND$

Then PWQ is the angle required, since PQ subtends equal angles at W and at the centre of the sphere of reference.

Again, suppose we wish to find the angle between two zones whose projections are TP and TQ. Draw OD perpendicular to TO and equal to r. Draw DN perpendicular to TD. Draw NPQ perpendicular to TN, and take W on TN such that $NW=ND$. Then PWQ is the angle required.

This result is important, for it shows that the gnomonic projection of the poles of a crystal can be readily constructed when we know the angles between its faces and zones; and that, conversely, when we are given the gnomonic projection, we can measure graphically the angles.

The result can be also applied at once to the graphical solution of spherical triangles, &c.

§ 5. Suppose we are given the gnomonic projection P of any pole of a crystal, and we wish to find the projection of the corresponding pole

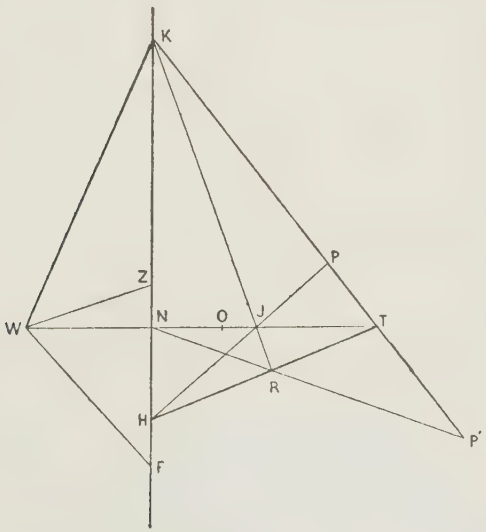


Fig. 3.

of a twin-crystal. Let the crystals be twinned about an axis meeting the plane of projection in T (fig. 3). Produce TO to N so that $TO \cdot ON = r^2$, and draw KNH perpendicular to TN meeting TP in K. Plot the intersection J of TN and HP, the intersection R of KJ and TH and the intersection P' of NR and PT. P' is the point required, since

the range (PP', KT) is harmonic, and TK subtends a right angle at the centre of the sphere of reference.

The lines TH, TN, IIK are drawn once for the whole crystal, and then only one line (TP) has to be drawn for each pole.

§ 6. Suppose now we wish to find the new projection of the pole when the crystal is rotated through an angle α (not $=180°$) about the axis. Take W on TN such that $WN^2 = NO \,.\, NT$. Make the angles $KWZ = \alpha$, $KWF = \frac{1}{2}(180° + \alpha)$. Then the point required is the intersection of PF and TZ.

§ 7. We now take the case of the stereographic projection.

It is easy, when we are given the stereographic projection of the zones and poles of a crystal, to find the gnomonic projection on a parallel plane and vice versa. For if the stereographic projection of a zone meets the principal circle j of the projection (whose radius is r and centre O) in E and F, and the tangents at E and F to the projection of the zone meet at S, the gnomonic projection of the zone is the straight line through S perpendicular to OS.

§ 8. Suppose we are given the circle j and the stereographic projections A, B, C, Q of the poles of the faces (100), (010), (001), (111). Let EF be the diameter of j passing through the intersection of BC with the common chord of j and any circle through B and C. Then the circle $BCEF$ is the stereographic projection of the zone $[100]$[1]. We can then by § 7 find the gnomonic projection of the zone $[100]$, and similarly of the zone $[0\bar{1}1]$. Let the straight lines OB, OC meet the former in B', C', and let OA, OQ meet the latter in A', Q'. Then A', B', C', Q' are the gnomonic projections of the poles of (100), (010), (001), (111) respectively. We can therefore find the gnomonic projection of any zone or pole by § 2 or § 3, and then we obtain the stereographic projection by § 7.

§ 9. An alternative to the method of § 8 is the following. Let the stereographic projections of the zones $[10\bar{1}]$ and $[\bar{1}10]$ meet the circle ABC in B_1 and C_1, and let the straight lines BB_1 and CC_1 meet in Q_1. Let the gnomonic projection of the zone $[HKL]$ for a crystal, such that A, B, C, Q are the gnomonic projections of the poles of (100), (010), (001), (111), meet the circle ABC in X and Y. Then the stereographic projection of the zone $[HKL]$ will pass through X and Y[2].

§ 10. Suppose we are given the stereographic projection P of any

[1] This construction solves the problem: 'Draw a circle through two given points bisecting the circumference of a given circle.'

[2] See Phil. Mag., 1905, ser. 6, vol. ix, p. 87.

pole of a crystal, and we wish to find the projection P' of the corresponding pole of a twin-crystal. Let T be the projection of the point in which the twinning-axis meets the sphere of reference (whose centre is O and radius is r as before). Draw WOU perpendicular to OT, such that $WO=OU=r$. Then, if the circles WPU, $WP'U$ meet OT in L and L', W bisects the angle LWL': this gives us the position of the circle $WP'U$. Or, again, if J, S, J' are the centres of the circles WPU, WTU, $WP'U$, SW bisects the angle JWJ'.

The results of the preceding sections hold good in general if we substitute 'extremity of the zonal axis $[hkl]$' for 'pole of the face (hkl)' and 'great circle whose plane is parallel to the face (hkl)' for 'zone $[hkl]$.'

§ 11. We now show how to construct the orthographic projection on a plane Π of a crystal whose faces $f_1, f_2, f_3, \ldots$ are at distances $p_1, p_2, p_3, \ldots$ from the centre C of the crystal. We consider p_1 positive or negative according as the perpendicular from C on f_1 makes an acute or obtuse angle with the perpendicular CO from C on Π; and so for $p_2, p_3, \ldots$. Construct the gnomonic projection of the poles on Π. Let $P_1, P_2, P_3, \ldots$ be the projections of the poles of the faces $f_1, f_2, f_3, \ldots$. Draw P_1Q_1 perpendicular to OP_1 and equal to r. On OQ_1 take $OR_1=p_1$, and draw R_1S_1 perpendicular to OQ_1 meeting OP_1 in S_1. Draw a line l_1 through S_1 perpendicular to OP_1. Construct lines $l_2, l_3, \ldots$ similarly. Then the line through the intersection of l_1 and l_2 perpendicular to the line P_1P_2 is the orthographic projection of the edge in which the faces f_1 and f_2 meet. Similarly we get the orthographic projection of all the edges.

Summary.

In this paper graphical constructions are given for the solution of the following problems:—

Given the gnomonic or stereographic projections of the poles of four faces, find the projection of the pole of any other face.

Given the gnomonic or stereographic projections of the poles of a crystal, find the projections of the poles of a twin-crystal.

Given the projection of two zones, find the angle between them.

Given the gnomonic projection of the poles of a crystal, find the orthographic projections of its edges, &c.

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Some applications of the Gnomonic Projection to Crystallography.

By Harold Hilton, M.A.
Fellow of Magdalen College, Oxford.

[Communicated by Professor Miers, and read November 15, 1904.]

1. LET the crystallographic axes OA, OB, OC of a crystal, whose axial ratios are $a:b:c$, meet a plane p in A, B, C. Let a plane through O, parallel to a crystal-face whose indices are h, k, l,

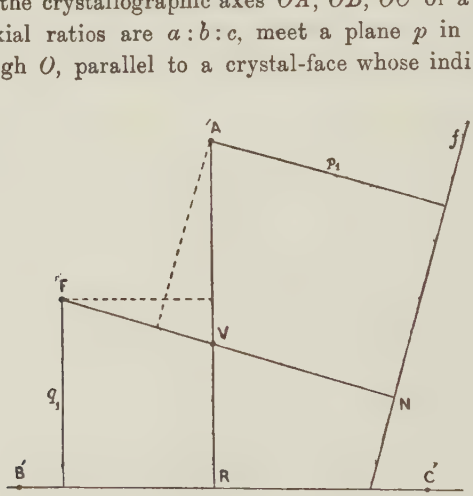

Fig. 1.

meet p in the line f (fig. 1); and let the line OF, perpendicular to the face, meet p at the point F. Let the perpendicular from O on p meet it in V, and let $OV = m$. Let

$$VOA = \alpha,\ VOB = \beta,\ VOC = \gamma,\ FOA = \lambda,\ FOB = \mu,\ FOC = \nu,$$
$$VOF = \theta.$$

Then $$h:k:l = a\cos\lambda : b\cos\mu : c\cos\nu.$$

Let FV cut f in N; then FN is perpendicular to f and $FV \cdot VN = m^2$.

Let the perpendiculars from A, B, C on f be p_1, p_2, p_3. Then

$$p_1 = VN + VA\cos AVF.$$

But $$VN = m^2 \div FV = m\cot\theta,\ VA = m\tan\alpha,$$
$$\cos AVF = (\cos\lambda - \cos\alpha\,.\,\cos\theta)\operatorname{cosec}\alpha\,.\,\operatorname{cosec}\theta,$$

by spherical trigonometry.

$$\therefore \quad p_1 = m \cos \lambda \,.\, \sec \alpha \,.\, \operatorname{cosec} \theta,$$

and $$\therefore \quad p_1 a \cos \alpha : p_2 b \cos \beta : p_3 c \cos \gamma = h : k : l.$$

Hence, if we take ABC as triangle of reference in the plane p and suitable triliteral coordinates (xyz), the equation of the line f is

$$hx + ky + lz = 0.$$

The indices of the edge in which the faces (hkl) and $(h'k'l')$ intersect are the same as the coordinates of the intersection of the lines whose triliteral equations are

$$hx + ky + lz = 0 \quad \text{and} \quad h'x + k'y + l'z = 0.$$

Therefore the line through O parallel to the edge $[HKL]$ meets p in the point (HKL).

Let the perpendiculars from O to the faces (100), (010), (001) meet p in $A'B'C'$. Then F is the pole of f, A of $B'C'$, B of $C'A'$, C of $A'B'$ with respect to a circle of radius $\sqrt{-m^2}$ whose centre is V[1]. Let q_1, q_2, q_3 be the perpendiculars from F on the sides of the triangle $A'B'C'$. Produce AV to cut $B'C'$ in R. Then

$$q_1 = VR + VF \cos AVF = m \cos \lambda \,.\, \operatorname{cosec} \alpha \,.\, \sec \theta$$

as before. Therefore

$$q_1 a \sin \alpha : q_2 b \sin \beta : q_3 c \sin \gamma = h : k : l.$$

Hence if we form the gnomonic projection on p of the poles and zones of the crystal which lie on a sphere of radius m whose centre is V, and if we choose a suitable triangle of reference on p and suitable triliteral coordinates, then the point (hkl) is the projection of the pole of the face (hkl) and $Hx + Ky + Lz = 0$ is the projection of the zone $[HKL]$.

The gnomonic projection of the poles and zones on p is the reciprocal polar with respect to a circle of radius $\sqrt{-m^2}$, whose centre is V, of the figure formed by drawing through O planes parallel to the faces cutting p in lines, and lines parallel to the edges cutting p in points.

2. We shall now take illustrations of the use of these theorems.

The anharmonic ratio of four cozonal faces $(h_1k_1l_1)$, $(h_2k_2l_2)$, $(h_3k_3l_3)$, $(h_4k_4l_4)$ is evidently equal to the anharmonic ratio of the range formed by the gnomonic projection of their poles. Now these four poles are the points $(h_1k_1l_1)$, &c., the triangle of reference being suitably chosen, and therefore the anharmonic ratio of the faces is equal to the anharmonic

[1] Since in a plane triangles reciprocal with respect to a circle are homologous, we have incidentally proved that the arcs joining corresponding vertices of a spherical triangle and its polar triangle are concurrent, and that the intersections of corresponding sides of the two triangles lie on a great circle.

ratio of the pencil formed by the lines joining these points to A', i. e., by the lines $yl_1 = zk_1$, &c. Therefore the anharmonic ratio of the four faces

$$= \left(\frac{k_3}{l_3} - \frac{k_1}{l_1}\right)\left(\frac{k_4}{l_4} - \frac{k_2}{l_2}\right) \div \left(\frac{k_4}{l_4} - \frac{k_1}{l_1}\right)\left(\frac{k_3}{l_3} - \frac{k_2}{l_2}\right)$$
$$= (k_1l_3 - k_3l_1)(k_2l_4 - k_4l_2) \div (k_1l_4 - k_4l_1)(k_2l_3 - k_3l_2).$$

Again project on to a plane perpendicular to an n-al rotation-axis of the crystal. Let A_1 be the projection of the pole of a face; then $A_2, A_3, A_4, \ldots, A_n$ are also projections of poles, $A_1A_2 \ldots A_n$ being a

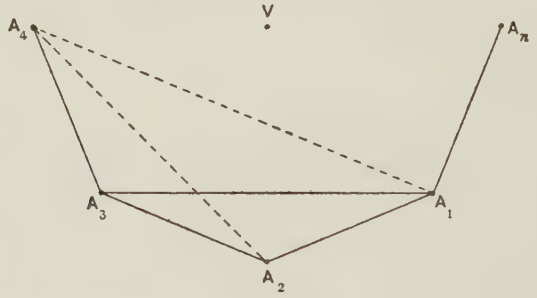

Fig. 2.

regular n-sided polygon (fig. 2). Take $A_1A_2A_3$ as triangle of reference. Then the areal coordinates of A_4 and A_n are

$$\frac{A_2A_3A_4}{A_1A_2A_3}, \quad \frac{A_3A_1A_4}{A_1A_2A_3}, \quad \frac{A_1A_2A_4}{A_1A_2A_3} \quad \text{and} \quad \frac{A_2A_3A_n}{A_1A_2A_3}, \quad \frac{A_3A_1A_n}{A_1A_2A_3}, \quad \frac{A_1A_2A_n}{A_1A_2A_3}.$$

But $A_3A_1A_4 = A_3A_1A_n$,

and $$\therefore \quad \frac{A_2A_3A_n}{A_2A_3A_4} = \frac{A_1A_2A_4}{A_2A_3A_4} = \frac{A_1A_4}{A_2A_3} = 1 + 2\cos\frac{2\pi}{n}$$

is rational. Therefore $n = 2, 3, 4$, or 6.

This proof may be readily extended to the case of symmetry-axes of the second sort (axes of alternating symmetry). It assumes neither the rationality of the anharmonic ratio of four cozonal faces nor the fact that the symmetry-axis is parallel to a possible edge.

3. Suppose we have n points in a plane, and suppose every pair of points joined by a straight line. Suppose that one of these lines passes through r of the points $P_1, P_2, \ldots, P_{r-1}, P_r$. Now if one of these points (P_r say) is moved out of the line, the total number of lines is increased by $(r-1)$; for the r lines $P_1P_r, P_2P_r, \ldots, P_{r-1}P_r, P_1 \ldots P_{r-1}$ replace the

single line $P_1 \dots I_r$. If now P_{r-1} is also moved out of the line, the total number of lines is increased by $(r-2)$ more lines, and so on. Suppose this process repeated until no line passes through more than two points; the number of lines is now $\frac{1}{2}n(n-1)$. Let u_r be the number of lines passing through r of the points and no more. Then we have

$$u_2+u_3+\dots+u_n = \tfrac{1}{2}n(n-1)-\sum_2^n\{(2+3+\dots+\overline{r-1})u_r\},$$

and therefore

$$n(n-1) = \sum_2^n r(r-1)u_r \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(i)}^1.$$

Again, in the above let v_r be the number of points at which r lines intersect, so that

$$\Sigma v = n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(ii)}.$$

Then the total number of lines would be

$$v_1+2v_2+\dots+(n-1)v_{n-1},$$

if we reckoned each line through r points as equivalent to r lines. Therefore

$$v_1+2v_2+\dots+(n-1)v_{n-1} = 2u_2+3u_3+\dots+nu_n,$$

or

$$\sum_2^n\{(r-1)v_{r-1}-ru_r\} = 0. \quad . \quad . \quad . \quad . \quad . \quad \text{(iii)}.$$

Combining (i), (ii), and (iii) we have

$$n = \sum_2^n r(v_{r-1}-u_r) \quad \text{and} \quad n(n-2) = \sum_2^n r(ru_r-v_{r-1}).$$

Suppose we have n lines in a plane, and suppose that every pair of lines intersects in a point. Let U_r be the number of points lying on r of the lines, and V_r the number of lines on which r points lie. Then by reciprocation

$$n(n-1) = \sum_2^n r(r-1)U_r, \quad \sum_2^n\{(r-1)V_{r-1}-rU_r\} = 0, \text{ \&c.}$$

Using the gnomonic projection we deduce the following:—

If on a crystal with n faces (two parallel faces being considered equivalent to only a single face) there are u_r zones containing r faces and v_r faces lying in r zones ($\Sigma v = n$), then

$$n(n-1) = \sum_2^n r(r-1)u_r, \quad \sum_2^n\{(r-1)v_{r-1}-ru_r\} = 0,$$

$$\sum_2^n r(v_{r-1}-u_r), \quad \text{and} \quad n(n-2) = \sum_2^n r(ru_r-v_{r-1}).$$

[1] Another proof is given by E. von Fedorow, Abhandl. k. bayer. Akad. Wiss. München, Math.-phys. Cl., 1900, vol. xx, p. 496.

Summary.

1. In the gnomonic projection of the poles of a crystal on any plane the projection of the pole of (hkl) is the point (hkl), and the projection of the zone $[HKL]$ is $Hx+Ky+Lz=0$, a suitable triangle of reference and suitable triliteral coordinates being taken.

2. By means of this theorem simple proofs of well-known crystallographic theorems may be obtained.

3. Some relations between the number (u_r) of zones of a crystal containing r faces, and the number of faces (v_r) lying in r zones may be found; e. g.,

$$n(n-1)=\sum_2^n r(r-1)u_r, \quad \sum_2^n\{(r-1)v_{r-1}-ru_r\}=0,$$

where $$\Sigma v_r = n.$$

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On an Epidote from Inverness-shire[1].

By H. H. Thomas, M.A., F.G.S.

[Read January 31, 1905.]

THE mineral to be described was found by Mr. C. T. Clough, M.A., of the Geological Survey, near the junction of the two large streams in Coire Dhorrcail, near Barrisdale on the south side of Loch Hourn, Inverness-shire[2].

Mr. Clough furnishes me with the following description of the mode of occurrence of the mineral:—

'The crystals were obtained from a band, which, although its sides are not well exposed, seems to form a nearly horizontal vein-like mass. This band crosses both the bedding and the foliation planes of the muscovite-biotite-gneiss in which it occurs, and which occupies a large area near Barrisdale and Ladhar Bheinn[3].

'The vein from which the specimens were obtained is the only one of its kind which has been met with in the district; it consists essentially of an aggregate of crystals, varying considerably in size, of the mineral epidote, together with red garnet, and white quartz with thin films of a dark green actinolite.

'Some of these masses are as much as ten feet in width and contain large crystals of epidote embedded in white quartz. Most of the better shaped crystals occur in this way. Many of the crystals are traversed by cracks almost at right angles to their long axis; the various parts have suffered displacement, while the cracks are filled with granular quartz. The largest crystal noticed lay in an aggregate of smaller crystals of the same character, and measured six inches long by two broad.'

Well formed crystals were chosen for analysis, the mineral being crushed and subjected to the separating action of a heavy fluid in order to remove any impurities in the form of included minerals of lower specific gravity. The following are the results of the analysis, kindly made by Dr. W. Pollard, of the Geological Survey:—

[1] Communicated by permission of the Director of H.M. Geological Survey.

[2] Ordnance Survey of Scotland, one inch map, sheet 61.

[3] Summary of Progress for 1900 (Memoir Geological Survey), 1901, p. 10.

Specific Gravity 3·37.

		Molecular ratios.	
SiO_2	39·02	0·646	6·00
TiO_2	trace		
Al_2O_3	28·64	0·2802	2·997
Fe_2O_3	6·81	0·0425	
FeO	0·34	0·0047	3·968
MnO	trace		
CaO	23·73	0·4238	
MgO	trace		
H_2O	1·76	0·0977	0·91
	100·30		

The above analysis gives the formula $Ca_4Al_6Si_6O_{25}H_2O$, in which the aluminium is partly replaced by ferric iron and the lime by ferrous oxide. Regarding the mineral as containing the group OH, we have

$$Ca_4Al_4(AlOH)_2(SiO_4)_6.$$

Dr. Pollard states that in the above analysis the ferrous oxide may be as much as 0·1 per cent. too low. As will be seen, the percentage of ferric oxide is very low for an epidote, and is only equalled by a few other epidotes, such as those from Huntington in Massachusetts[1], and the Zillerthal in the Tyrol[2].

The crystals are dark grey to greyish-brown in colour, but yield an almost white powder. They show a marked prismatic development, being elongated in the direction of the axis of symmetry, and attain in some instances, as has already been stated, a length of six inches. The faces of the orthodiagonal zone are by far the most strongly developed and form in most cases six- or four-sided prisms. Some of the smaller crystals are terminated, usually by simple forms.

The following are the faces which have been identified on the crystals measured:—

$a\{100\}$	$i\{\bar{1}02\}$
$c\{001\}$	$m\{110\}$
$r\{\bar{1}01\}$	$n\{\bar{1}11\}$
$f\{\bar{3}01\}$	$o\{011\}$

All these forms were noticed on one crystal, but the more common habit is represented by those crystals bounded by the faces *a c r n*.

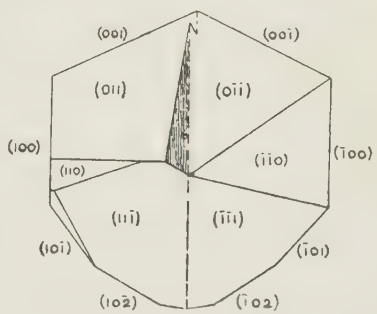
[1] E. H. Forbes, Amer. Journ. Sci., 1896, ser. 4, vol. i, p. 26.
[2] H. Laspeyres, Zeits. Kryst. Min., 1879, vol. iii, p. 562.

Below are given the chief measured angles as compared with those calculated from the axes of N. von Kokscharow, junr.[1], viz.:—

$a : b : c = 1{\cdot}57874 : 1 : 1{\cdot}80362$; $\beta = 64° 36' 50''$.

	Measured.	Calculated.
$ca = (001):(100)$ . . .	64° 37′ . . .	64° 36′ 50″
$am = (100):(110)$ . . .	54 48 . . .	54 59 54
$cn = (001):(\bar{1}11)$ . . .	75 3 . . .	75 11
$cr = (001):(\bar{1}01)$ . . .	63 49 . . .	63 42
$ci = (001):(\bar{1}02)$ . . .	34 38 . . .	34 21
$cf = (001):(\bar{3}01)$ . . .	98 16 . . .	98 37
$a'r = (\bar{1}00):(\bar{1}01)$ . . .	51 34 . . .	51 41
$a'n = (\bar{1}00):(\bar{1}11)$ . . .	69 5 . . .	69 2

All these angles were measured on crystals of small size and with bright faces, which gave for the most part good reflections. Only occasionally are the faces in the orthodiagonal zone striated parallel to the zone-axis. The larger crystals are much less perfectly developed, their faces are more irregular, and those of the orthodiagonal zone more deeply striated. The faces of $c\{001\}$ are usually bright and without irregularities.



Epidote from Inverness-shire. (Terminal faces of a small twinned crystal).

The mineral has a perfect cleavage parallel to c (001) and a less perfect one parallel to a (100).

Many of the crystals are simple twins with a twin-axis perpendicular to (100) and have (100) as the plane of composition. Polysynthetic twinning is by no means uncommon, following the same law.

A section cut parallel to the plane of symmetry gave the following extinctions for white light:—

Extinction measured to the trace of the good cleavage c (001), 23° 20′, and to the trace of the face a (100), approximately 1°.

The axis of least elasticity c was seen to make nearly a right angle with the face a (100),

therefore $a : c = 1°$ approximately.

[1] Verh. russ. min. Ges., 1880, ser. 2, vol. xv, p. 47. The position taken above is not used in Dana's 'System of Mineralogy,' 6th edit., 1892, p. 516.

Owing to this small angle the polysynthetic character of the twinning is far from easy to recognize in sections cut at right angles to the twin-lamellae; but between crossed nicols sections, which are thin enough to show the bright colours of the lower orders, will appear banded, the lamellae say alternately blue and red.

The optical constants were determined from a single crystal, which showed twin-lamellae: fortunately the lamellae were thick enough to permit measurements being made on untwinned parts of the crystal.

For the determination of the refractive indices, two prisms were cut by Mr. John Rhodes. One with a face parallel to (010) and its refracting edge parallel to the **a**-axis, and the other with a face perpendicular to **c** and its refracting edge parallel to the axis of symmetry, or **b**, of the crystal. The first prism placed with the face (010) perpendicular to the incident light gave for sodium-light $\alpha = 1{\cdot}714$ and $\gamma = 1{\cdot}725$. By means of the second prism β for sodium-light was found to be $\beta = 1{\cdot}7196$.

The indices of refraction for yellow light are therefore:—

$$\alpha = 1{\cdot}714, \qquad \beta = 1{\cdot}7196, \qquad \gamma = 1{\cdot}725,$$

giving the relatively very low double refraction

$$\gamma - \alpha = 0{\cdot}011.$$

A plate cut perpendicular to **a** gave, in cassia oil[1], $2H_a = 98^\circ\ 16'$ for sodium-light. This, with the above value for β, gives for the value in the crystal:—

$$2V_a = 89^\circ\ 35'.$$

For thallium-light in cassia oil[2], $2H_a = 98^\circ\ 18\frac{1}{2}'$; $2V_a$ therefore for thallium-light $= 90^\circ\ 29'$.

The dispersion is slightly inclined; $v > \rho$. The optical character is negative for sodium-light, but positive for thallium-light.

The pleochroism is very distinct: for rays vibrating parallel to **b**, in sections 0·5 mm. thick, pale plum-colour; for those parallel to **a**, very pale plum-colour; and parallel to **c**, pale greenish-yellow, yellow predominating. The pleochroism scheme is therefore:—

$$\mathbf{b} > \mathbf{a} \gtrless \mathbf{c}.$$

A comparison of the epidote from Inverness-shire with those from Huntington, Zillerthal, and Val Maigels (Switzerland) brings out many points of interest, and shows a striking similarity in the chemical compositions. Below are given the analyses of the four epidotes in question.

[1] The refractive index of the oil for sodium-light = 1·60273 at 18°C.

[2] The refractive index of the oil for thallium-light = 1·61461 at 18°C.

	Inverness-shire.	Huntington.	Zillerthal[1].	Val Maigels[2].
SiO_2	39·02	37·99	38·46	39·07
Al_2O_3	28·64	29·53	28·59	28·90
Fe_2O_3	6·81	5·67	5·76	7·43
FeO	0·34	0·53	0·53	—
MnO	trace	0·21	—	—
CaO	23·73	23·85	24·60	24·30
MgO	trace	—	—	0·10
H_2O	1·76	2·04	1·92	0·63
	100·30	99·82	99·86	100·43
Specific gravity	3·37	3·367	—	3·361

The pleochroism of the Inverness mineral is identical with that described by Forbes in the epidote from Huntington, and is very similar to that of the pale green crystals from the Zillerthal.

The mineral under investigation forms an interesting member of those epidotes with a low percentage of ferric iron, and falls naturally into the series. It has been recognized for some time that in the case of the epidotes the percentage of ferric iron has a direct influence on the refractive indices of the mineral, and on the other optical constants: namely, that with an increase in the percentage of Fe_2O_3 the values of the refractive indices and of the double refraction increase, while the dependent value of the angle between the optic axes measured over **a** decreases. A comparison of the Inverness epidote with those of Untersulzbachthal[3], Zillerthal[4], and Huntington[4], clearly illustrates the more or less gradual change in the optical constants (for sodium-light) as the percentage of ferric oxide decreases.

	Fe_2O_3.	α.	β.	γ.	$\gamma-\alpha$.	2V.
Untersulzbachthal	14·0	1·7305	1·7540	1·7677	0·0372	73° 39′
Zillerthal	6·97	1·720	1·7245	1·7344	0·0144	87 46
Inverness-shire	6·81	1·714	1·7196	1·725	0·011	89 35
Huntington	5·67	1·714	1·716	1·724	0·010	90 32

In the Huntington mineral the acute bisectrix is **c** and the optical character positive, so that measured over **a** the angle between the optic axes is 90° 32′.

[1] H. Laspeyres, loc. cit.

[2] G. vom Rath [Grey epidote from Val Maigels], Zeits. Deutsch. geol. Gesell., 1862, vol. xiv, p. 428. See also E. Weinschenk, 'Ueber Epidot und Zoisit,' Zeits. Kryst. Min., 1896, vol. xxvi, p. 176.

[3] C. Klein, Neues Jahrb. Min., 1874, p. 1.

[4] E. H. Forbes, loc. cit.

The band from which the Inverness-shire specimens were obtained is on the Kneydart estate, the property of the late Mr. E. S. Bowlby; and Mr. Clough and myself wish to express our thanks to the factor, Mr. Stewart, for his kindness in ordering a blast to be put into the band referred to. My thanks are also due to my colleague Mr. O. T. Jones, who helped me considerably in my investigations.

REVIEWS.

Manual of the Chemical Analysis of Rocks. By Henry S. Washington, Ph.D. Pp. ix + 183. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd., 1904. Price 8*s.* 6*d.* net.)

Of late years it is to the United States that we have learned to look for improved methods of manipulation and separation in the chemical analysis of inorganic bodies. In the case of rocks, the most recent and approved methods of analysis employed by the chemists of the United States Geological Survey have been made generally accessible by the recent publication of Hillebrand's admirable treatise. At first sight, therefore, there would appear to be little justification for this work of Dr. Washington's on precisely the same subject. The author, however, claims for his book that it has been written for that increasing class of petrologists and others who would like to make analyses of rocks, but who have had little or no experience in the subject, whereas Hillebrand's treatise is intended for the practised analyst. As one of the joint authors of that remarkable system of rock-classification, depending mainly on chemical composition, which has recently astonished the petrographical world, he is naturally anxious to render 'data in the way of rock analyses of superior quality more numerous.' In good hands the book, with its clear exposition of modern chemical methods, should certainly conduce to this desirable end, but, as it is avowedly intended to supply the student with such minutiae of detail that he may dispense with personal instruction, there is some cause to fear lest unskilled and careless workers be encouraged by its aid to perpetrate analyses of rocks and to publish their results. We are inclined to think that the chemist who is sufficiently advanced to produce trustworthy results will not require any more details than are given in Hillebrand's treatise. The book is nevertheless very welcome as a further means of making recent methods of rock analysis more widely known, for it is admirably written from the point of view of clearness and minuteness of detail. The student could have no better training in analytical methods than would be afforded by the guidance of this book in the analysis of an igneous rock, and it can be recommended to college professors who can spare little time for personal instruction to their students, since the directions given are very explicit and descend to such details as the sizes of beaker, filter-paper, and evaporating dish to be used in the various operations.

A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection, in the Museum of Practical Geology, Jermyn Street, London, S.W. By F. W. Rudler, I.S.O. Pp. x + 241. (London: H.M. Stationery Office, 1905. Price 1*s.*)

An interval of almost half a century having elapsed since the publication, in 1858, of Greg and Lettsom's 'Manual of the Mineralogy of Great Britain and Ireland,' a new work on British minerals is specially welcome. The work is primarily intended as a handbook to a collection of minerals arranged by Mr. Rudler, since his retirement from his long held post of curator, in the Museum of Practical Geology. The book will have a permanent value as a treatise, for it is by no means a mere catalogue or descriptive list of all the specimens in the collection, nor is it, like Greg and Lettsom's manual, a descriptive mineralogy with complete lists of the localities of British minerals. Rather is it an extremely readable and interesting account of the mode of occurrence and history of British minerals, with special reference to their paragenetic relations, and their probable modes of origin, and with only brief reference to specific characters.

The mode of treatment is distinctly novel, the minerals being classified according to geographical distribution. Half the total number of minerals in the collection come from Cornwall and Devon, and about half the book is devoted to the consideration of these specimens. The remainder deals with minerals from the other mining districts of England, and includes a chapter on the minerals of the Neozoic strata, and short accounts of various mineral localities in Scotland, Ireland, and the Isle of Man. Under Cornwall and Devon the main headings are as follows :—cassiterite ; minerals associated with cassiterite ; copper sulphides and sulpho-ferrites ; copper-bearing minerals of the gozzans ; arsenates and phosphates from the copper-gozzans ; ores of lead, zinc, antimony, &c. ; sulphides and sulpho-salts ; ores of iron, &c. ; minerals of the rarer metals ; the spars of the mineral veins ; miscellaneous minerals.

The breadth and comprehensiveness of this work render it valuable not only to mineralogists, but also to geologists and to those interested in mining, while the numerous references to original papers furnish abundant evidence of the care and patience which have been bestowed upon its preparation.

Minerals of Japan. By Tsunashirō Wada. Translated by Takudzi Ogawa. Pp. vii + 144, with 30 + 4 plates. (Tōkyō, 1904.)

This attractive-looking volume contains descriptions of 131 mineral species found in Japan, giving details of their mode of occurrence at the various localities, together with particulars relating to crystalline form and chemical composition. Much of the matter has been previously published in Japanese journals, but has not hitherto been accessible to European mineralogists; there are, for example, numerous chemical analyses of minerals which have not appeared before in a European language. The book, which is written in English, may be considered to be an extension of K. Jimbō's paper 'Notes on the minerals of Japan' (Journ. Sci. Coll. Univ. Tōkyō, 1899, vol. xi, pp. 213–281).

The excellent collotype plates, prepared from photographs of specimens in the author's collection, show very clearly the characteristic features of the minerals they represent. Special mention may be made of those representing the well-known Japanese minerals stibnite, rock-crystal in simple and twinned groups, topaz, and orthoclase. In addition to the plates, the text is well illustrated by outline figures of crystals.

Under the name naegite a new species is described from the alluvial tin washings at Naegi, near Takayama, in the province Mino. It is a silicate of uranium and thorium with some tantalum and niobium; the crystals appear to be tetragonal and isomorphous with zircon and thorite.

An examination of the mineral reinite, which has been described only from Japan, shows that it is not tungstate of iron crystallizing in the tetragonal system, but a pseudomorph of wolframite after scheelite, like the well-known pseudomorphs from Trumbull in Connecticut.

Since mineralogy was first taught in Japan by Karl Schenk, John Milne, and others, thirty years ago, considerable advances have been made in the science, and there are now several expert Japanese mineralogists, facts which the book before us amply testifies.

For information respecting Japanese localities of minerals the book will be found especially useful.

NOTES.

The following deaths have to be recorded:—

Ronald William Henry Turnbull Hudson (1876–1904) met with a fatal accident on September 20 of last year while climbing in North Wales. He was the only son of Professor W. H. H. Hudson, of King's College, London, and after a distinguished mathematical career at Cambridge, where he was Senior Wrangler in 1898 and a Fellow of St. John's College, he was appointed Lecturer in Mathematics in the University of Liverpool. Although not a member of our society, he contributed to vol. xii of the magazine (with a supplementary note in vol. xiii) a mathematical paper having a bearing on crystallography.

Theodor Heinrich Behrens (1842–1905), since 1875 Professor of Microchemistry in the Polytechnic School at Delft in Holland. He was the recognized authority on microchemical methods of analysis, as applied, not only to minerals, but to a great variety of inorganic and organic substances, on which subject he published many memoirs and books; 'A manual of microchemical analysis' was published in English in 1894. In the same connexion he wrote on crystallites, and on the micro-structure of metals and of diamond; and was also the author of several papers on the petrography of the Dutch East Indies.

Joseph Patrick O'Reilly (1829–1905), for more than thirty years (1868–1899) Professor of Mining and Mineralogy in the Royal College of Science for Ireland, was born in the town of Monaghan on July 11, 1829, and died in Dublin on January 6, 1905. He was educated in Paris as a civil engineer, and for some years acted as engineer to mining companies in Spain, first at the zinc mines of Santander and afterwards at the sodium sulphate mines near Madrid. The results of the observations made by him in these districts were published, in conjunction with Dr. W. D. Sullivan, in 1863. He was the author of several papers on Irish minerals (one of which appeared in vol. xi of this magazine), but his work in other directions—in archaeology and in various branches of geology—showed that he had very wide interests. Professor O'Reilly was a most enthusiastic teacher and was much loved and respected by his pupils.

An interesting discovery of cassiterite has been made in eastern Ross-shire by the members of the Geological Survey. This mineral has hitherto not been recorded from Scotland, and the discovery is

of further interest on account of the unusual mode of occurrence of the mineral. The foliated granite-gneiss of Carn Chuinneag contains streaks and veins of granular magnetite, intermixed with which is cassiterite in amounts varying up to 17 per cent. This magnetite-cassiterite-rock has a foliated structure marked out by the interlamination of small quantities of quartz, felspars, micas, and rutile. A preliminary description of the occurrence is given in the 'Summary of Progress of the Geological Survey' for 1903 (1904, pp. 58, 81), and a special exhibit of specimens, maps, and photographs has been arranged in the Museum of Practical Geology.

An aegirite-riebeckite-gneiss has also been found in the granite-gneiss complex of the same district; this rare variety of hornblende-gneiss has not before been observed in the British Isles. Several other points of mineralogical interest might be mentioned from the volume quoted, for example, the discovery *in situ*, in a dyke-rock, of the withamite of Glencoe.

The enormous diamond found in the Premier mine in the Transvaal on January 25, 1905, has been described by Drs. F. H. Hatch and G. S. Corstorphine in the 'Geological Magazine' (April, 1905, pp. 170–172, plates vii and viii); their account is accompanied by process illustrations showing the stone in actual size from four different points of view. The stone weighs $3024\frac{3}{4}$ carats (=9600·5 grains or 1·37 lb. avoirdupois), and measures 4 by $2\frac{1}{2}$ by 2 inches. It is a portion, probably not more than half of the original crystal, of a distorted octahedron, and is bounded by four natural octahedral faces and by four cleavage surfaces; the former are marked with striations parallel to the octahedral edges, and with triangular etched pits. The crystal is of remarkable purity and approximates in colour to the so-called blue-white.

The largest diamond previously known is the 'Excelsior,' a stone of $971\frac{3}{4}$ carats, found in 1893 in the Jagersfontein mine, Orange River Colony. The size of the newly found stone considerably exceeds that assumed for the originals of the famous Indian diamonds, the 'Great Mogul' and the 'Koh-i-noor.'

An account of the new Premier mine, which is situated about twenty miles WNW. of Pretoria, has recently been published in the Report for 1903 of the Geological Survey of the Transvaal (Pretoria, 1904, p. 43). It is of the same type as the Kimberley mines, but much larger in size, the pipe containing the 'blue ground' measuring over half a mile along the longer diameter of its oval-shaped cross-section, the area of which is

estimated at 350,000 square yards. The pipe breaks through felsitic rocks which were earlier intruded in the quartzites of the Pretoria series.

A report on the progress of mineralogical chemistry during the year 1904 has been contributed by Dr. A. Hutchinson to the new volume of 'Annual Reports on the Progress of Chemistry' issued by the Chemical Society of London (1905, vol. i, pp. 222–244). Under the heading 'General and physical chemistry of minerals' are given reviews of the recent work of van't Hoff on oceanic salt deposits, of Judd and Cullis on dolomitization in coral reefs, and of Vogt on the crystallization of minerals in slags and molten mixtures of silicates. Brief descriptions are given of the new mineral species described in 1904, and some of the more important analyses of older minerals are quoted. A summary is given of recent work relating to the radio-activity of minerals, the artificial production of minerals, and several other points of interest. A list of meteorites analysed during the past year is also given.

A new mineralogical journal has appeared under the title 'Beiträge zur Mineralogie von Japan'; it is issued from Tōkyō by T. Wada. The first number, dated January, 1905, contains two papers by K. Jimbō, one on the crystalline form and etched figures of the fine crystals of danburite from Obira, and the other on the siliceous oolite of Tateyama; both papers are written in English and are illustrated with several figures. Short notes on Japanese minerals and on Chinese gem-stones are contributed by T. Wada, who writes in German.

A detailed and instructive account of the practical methods of drawing crystals is given by Professor S. L. Penfield in the American Journal of Science (1905, ser. 4, vol. xix, pp. 39–75). He has designed a special protractor for plotting crystallographic axes, and some special triangles for drawing lines parallel to these axes. The advantages of drawing an orthographic projection or plan in conjunction with a clinographic projection is specially insisted upon: this was first done by Koksharov in 1853 in his 'Materialen zur Mineralogie Russlands,' and has been used in this volume at p. 44.

The formula, Cu_3FeS_3, up to the present accepted for the common mineral bornite or erubescite is based on analyses made in 1839 on

Cornish crystals. Professor B. J. Harrington (Amer. Journ. Sci., 1903, ser. 4, vol. xvi, pp. 151–154) shows that this formula needs revision; his analyses of massive bornite from several Canadian localities, and of crystallized material from Bristol, Connecticut, lead to the new formula Cu_5FeS_4. The old formula is readily explained by the fact that the Cornish crystals are always impure and usually contain a nucleus of chalcopyrite ($CuFeS_2$).

A natural occurrence of the artificial product known as carborundum, first prepared in 1893 by E. G. Acheson, and extensively used, on account of its extreme hardness, as an abrasive agent, has recently been noted by Professor H. Moissan (Compt. Rend. Acad. Sci. Paris, 1904, vol. cxxxix, p. 778; 1905, vol. cxl, p. 405). It was found by him in association with diamond in the meteoric iron of Cañon Diablo, Arizona, as small, green, hexagonal plates, identical in characters and composition with the artificial silicide of carbon (CSi). For this new meteoric mineral Dr. G. F. Kunz has proposed the name moissanite.

Fiedlerite, a mineral found in 1887 by G. vom Rath in the ancient lead slags of Laurion, Greece, where it is associated with the closely allied minerals laurionite ($PbCl_2.Pb(OH)_2$), paralaurionite, and penfieldite ($2PbCl_2.PbO$), has recently been analysed for the first time by A. de Schulten (Compt. Rend. Acad. Sci. Paris, 1905, vol. cxl, p. 315). His analysis leads to the formula $2PbCl_2.Pb(OH)_2$.

New names are still being given to imperfectly described minerals, but it is satisfactory to observe that many of these doubtful species, as well as some earlier ones, are being proved to have no existence. Such names need, therefore, only burden the lists of synonyms in the larger works of reference. Amongst identities recently proved, or suggested on good grounds, the following may be noted:—

Conchite = aragonite (R. Brauns, Centralblatt Min., 1901, p. 134; H. Vater, Zeits. Kryst. Min., 1901, vol. xxxv, p. 149).

Coolgardite = coloradoite + calaverite, &c. (L. J. Spencer, Min. Mag., 1903, vol. xiii, p. 268).

Dimorphite = orpiment (S. Stevanović, Zeits. Kryst. Min., 1904, vol. xxxix, p. 18).

Goldschmidtite = sylvanite (C. Palache, Amer. Journ. Sci., 1900, ser. 4, vol. x, p. 422).

Hessenbergite = bertrandite (F. Grünling, Zeits. Kryst. Min., 1904, vol. xxxix, p. 386).

Huelvite = rhodochrosite + tephroite (Chemiker-Zeitung, 1903, Jahrg. xxvii, p. 15).

Hussakite = xenotime (E. Hussak and J. Reitinger, Zeits. Kryst. Min., 1903, vol. xxxvii, p. 563).

Hydrogiobertite = brucite + ? (L. Brugnatelli, Centralblatt Min., 1903, p. 148).

Kalgoorlite = petzite + coloradoite (L. J. Spencer, Min. Mag., 1903, vol. xiii, p. 268).

Kilbrickenite = geocronite (G. T. Prior, ibid., 1902, vol. xiii, p. 186).

Ktypeite = aragonite (H. Vater, Zeits. Kryst. Min., 1901, vol. xxxv, p. 149).

Lacroisite = rhodochrosite + rhodonite (Chemiker-Zeitung, 1903, Jahrg xxvii, p. 15).

Lussatite = tridymite (F. Slavík, Centralblatt Min., 1901, p. 690).

Mamanite = polyhalite (J. H. van 't Hoff and G. L. Voerman, Sitz.-ber. Akad. Wiss. Berlin, 1904, p. 984).

Martinite = monetite (A. de Schulten, Bull. Soc. franç. Min., 1901, vol. xxiv, p. 325).

Metabrushite = brushite (A. de Schulten, ibid., 1903, vol. xxvi, p. 14).

Mooraboolite = natrolite (Min. Mag., 1903, vol. xiii, p. 373).

Palacheite = botryogen (A. S. Eakle, Amer. Journ. Sci., 1903, ser. 4, vol. xvi, p. 379).

Plusinglanz = argyrodite (A. Frenzel, Min. petr. Mitt. (Tschermak), 1900, vol. xix, p. 244).

Ramosite = basic volcanic scoria (L. McI. Luquer, Amer. Journ. Sci., 1904, ser. 4, vol. xvii, p. 93).

Reinite = wolframite pseudomorphous after scheelite (T. Wada, Minerals of Japan, Tōkyō, 1904, p. 76).

Simonyite = blödite (F. M. Jaeger, Min. petr. Mitt. (Tschermak), 1903, vol. xxii, p. 103).

Tamanite = anapaite (Zeits. Kryst. Min., 1903, vol. xxxvii, p. 267).

Torrensite = rhodochrosite + rhodonite (A. Lacroix, Bull. Soc. franç. Min., 1900, vol. xxiii, p. 254).

Viellaurite = rhodochrosite + tephroite (A. Lacroix, ibid., 1900, vol. xxiii, p. 253).

Wapplerite = rösslerite (A. de Schulten, ibid., 1903, vol. xxvi, p. 99).

Warrenite = jamesonite (L. J. Spencer, Nature, 1904, vol. lxix, p. 575).

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